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Contents of previous issues of the JOURNAL OF ANIMAL SCIENCE are indexed in the Agricultural Index, which is available in most libraries.

COOPERATION IN ANIMAL HUSBANDRY RESEARCH[1]

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MAY I preface this discussion by a disclaimer, one quite unnecessary to those who know me, though it may be advisable to others. There is *nothing* in my background of training or experience which would qualify me to speak with authority on many of the technical aspects of animal production or of animal husbandry. Any competency that I may bring to a discussion of the topic assigned me must come under the heading of administration. This means that there will be lacunae in my presentation; these I hope may be filled in by the other speakers on this program, men who have greater technical competency.

I trust that our program-makers intended that we discuss cooperation in animal husbandry research with the expectation that we would do something about it, and did not expect us merely to recite history. We should, if possible, analyze our situation to determine whether cooperation is a real help, a necessary tool. If it is, we should debate how it may be made more effective.

First, what are the agencies that are responsible for carrying on research in animal husbandry? Our theme is a discussion of their inter-relationships. We should also note the groups or agencies for whom the researches are carried forward, those that will make use of them.

The most numerous of the research agencies for animal husbandry are the several state and territorial agricultural experiment stations, about 52 of them I believe, created in every instance by specific action of the respective state legislatures. All receive research funds directly from the state, as well as grant-in-aid funds from the Federal Government. The determination of what subjects are to be investigated is made by the stations themselves, within the boundaries set by law, both state and federal, relative to use of funds. I emphasize this autonomy of the state stations. Their administration is not tied closely to the Federal Government—by no means as closely, for example, as is that of the Agricultural Extension Service. These experiment stations have considerable resources in funds. Each expends annually more than 100 thousand dollars on its research; some spend considerably more than a million. If one should attempt to capitalize, say at 4 per cent, the annual expenditures for research by these stations to determine the equivalent endowment that would be necessary to maintain the income, such endowment would amount to more than half a billion dollars. Even in wartime that is a sum large enough to demand some attention. I have no adequate

[1] One of a series of three papers on cooperative animal research and regional laboratories, presented before the opening session of the annual meeting of the American Society of Animal Production, December 1, 1944.

data that would tell what proportion of the annual expenditures of the stations is devoted to research in animal husbandry in its many aspects, but I suspect that it would require an endowment of a hundred million dollars or more to maintain our present research output in this field. Obviously, if there is to be adequate coordination in the program, if inadvisable duplication is to be avoided, the stations should work together and plan together. And gradually there have developed some techniques for handling cooperation. These should be clearly understood by all our workers in animal husbandry research.

Even before the passage of the Hatch Act, which gave the first federal aid to the stations, the directors of newly established experimental farms and stations began meeting to discuss their problems; in fact, it was from an Association of Experiment Stations that the Association of Land-Grant Colleges developed. In the early days funds were limited, and much time was spent (and profitably) on over-all problems of organization. The directors of the stations have maintained that organization and have met annually for more than a half century. Many years ago a joint committee of the U.S.D.A. and the station directors was constituted, called the Committee on Projects and Cooperation in Research. It did valiant service for many years, as we shall see when we look at the problem of state-federal relationships. Later the land-grant colleges instituted a Committee on Organization and Policy. Still later the two committees were united, and the new committee has had considerable influence in facilitating coordination.

Two events have led to marked increases in cooperation on a regional basis. The first of these was a meeting which resulted from a call by the then Secretary of Agriculture Henry Wallace. He asked, about ten years ago, that a concerted effort be made by the land-grant colleges to prepare an over-all classification of land and agricultural production capabilities under best uses of resources. He threw down a challenge for states to work together to get regional results. And directors of the stations in the several agricultural regions organized on a somewhat definite basis to work together on the problem. Some regions, as the Northeastern, had a long history of a directors' association; in other regions there never had been a meeting.

The second event which tended to bring the station directors together on a regional basis was the passage of the Bankhead-Jones Act by Congress. This caused the states and station directors immediately to face the problem of planning the inauguration of a series of regional laboratories. Each one of the laboratories was, in fact, established as the result of the unanimous recommendation of the states in one or two regions. For each of these Bankhead-Jones laboratories a technical advisory committee was constituted, made up of one collaborator designated by each station. These

aboratories and the technical committees made it necessary for the stations to work ever more closely together on problems of regional significance.

A little later the Secretary of Agriculture was directed by Congress to create four agricultural regions, to be serviced by four regional laboratories, to study problems of crop surpluses. And the station directors were designated in each of the regions as an advisory committee to these laboratories. The necessity of considering many problems on a regional basis became increasingly evident.

The depression and the war have brought new pressures upon the stations in their respective regions to do things together. Some regions have found it necessary to do more than others. In the North Central Region, the Corn Belt, a considerable number of cooperative projects among several to as many as fourteen states have been developed. The results of these cooperative studies in at least two regions are being published in regional series of bulletins. Reports are made at the semi-annual meetings of the directors of the region.

It is apparent that through the years there has been developed a group of powerful state agencies, the agricultural experiment stations, that have learned at least some of the elementary lessons of cooperation.

A second series of agencies significant in agricultural research (including animal husbandry research) are the regular bureaus of the U. S. Department of Agriculture. Congress has definitely assigned to the Department of Agriculture many research functions. For years there was a large amount of autonomy on the part of these bureaus, and their development took many courses. One of the first discoveries on the part of a newly appointed experiment station director was that he had to deal with different historical backgrounds and different concepts of research and cooperation in each of the dozen or so bureaus of the U.S.D.A. This situation, of course, had its counterpart in the fact that each bureau chief found himself dealing with about fifty station directors, each in turn a problem. However, the Office of Experiment Stations of the U.S.D.A. has had as chief a succession of unusually able agricultural research statesmen. Relationships have been worked out with reasonable satisfaction. These bureaus had quite different developments. The Bureau of Plant Industry, for example, apparently not hampered by any great action program to administer, almost from the beginning began to cooperate with the state stations and has, from our standpoint, a most satisfactory record. Several factors led to a quite different type of development on the part of the Bureau of Animal Industry. Almost from the beginning it was loaded with the task of handling one of the most important action programs, that of meat inspection. This inspection in and of itself did not entail research to any great extent. It did involve the employment of a host

of meat inspectors. It was thought wise for some reason to insist that these should be veterinarians. And I believe that Congress also specified that the chief of the bureau should be a veterinarian. We have had able men at the head of the bureau. I don't believe that better could have been found. But this allocation of a police function to the bureau and the continued emphasis upon professional training in veterinary medicine on the part of most of its workers was not entirely fortunate from the standpoint of development of agricultural research. The setup, the atmosphere, the morale of an administrative police agency is not conducive to research. And though there were some notable contributions to a knowledge of animal diseases, as Texas fever and hog cholera, it is only within recent years that there has been developed an adequate research staff to deal with the many important problems of animal industry as a whole. The experience in cooperation with states has had to be developed much more recently. But I believe it has come a long way in a short time. Fifteen years ago the Bureau of Animal Industry would have ranked near the bottom from the standpoint of leadership in animal industry research; in fact, the leadership quite definitely was with the agricultural experiment stations. This statement does not hold now. Personally I would rank the bureau near the top. It has succeeded in ever better segregation of its research from its police functions.

There has been an increasing tendency in recent years for the Department of Agriculture to secure better integration of research, first through a director of research and now a research administrator. And increasingly the best techniques of cooperation of each bureau are being communicated to others.

Don't get the idea that I feel that on the national level all research relevant to animal production is in the Bureau of Animal Industry. Some of it definitely is in other bureaus, as the Bureau of Agricultural Economics, the Bureau of Plant Industry, Soils and Agricultural Engineering, the Bureau of Agricultural and Industrial Chemistry and the Bureau of Human Nutrition and Home Economics. And some even is to be found in agencies which were set up primarily as action programs, such as the Agricultural Adjustment Administration and the Soil Conservation Service. Cooperative relationships with these latter, even as they affect somewhat indirectly animal industry, are poorly and imperfectly worked out. Probably we may ascribe our present difficulties in developing right relationships to them to their immaturity.

The national Congress in its Bankhead-Jones Act authorized appropriations to the Secretary of Agriculture for the development of regional laboratories for study of problems too extensive to be handled by single stations. These have proved to be among the most successful of cooperative

enterprises involving the U.S.D.A. and the state stations. As noted above, these have been established at the unanimous request of the states in the regions concerned. Several of them primarily service animal industry. Each was established on the basis of a memorandum of understanding including the Bureau of Animal Industry and all of the stations of the region. The laboratories are not all of the same type. The cooperation differs. Some are highly centralized; some not at all. They have been designed to the best of the combined ability of state and nation to do the job agreed upon. Let's look at two or three.

At the request of the Western Region, a laboratory for sheep breeding was set up in Idaho. The Federal Government already owned a considerable tract of land. It was agreed that all of the efforts should be centered on one locality. An advisory committee representing the stations of the states of the region was appointed and is functioning. The work of the laboratory, I am told by some of the station directors, is proceeding quite satisfactorily. The technique of management adopted has proved good. The cooperation on the part of the states is that necessary to get the job done, but little or none of the work is done at the state stations. Supervision is cooperative, but little of the work is.

On the other end of this series, in the North Central Region, is the Regional Swine Breeding Laboratory. Several of the stations in this region had made a substantial beginning in breeding programs. It was recognized almost from the first that it would be difficult to carry on satisfactorily the whole research at one place; the area of land needed would be too great for efficient management; the opportunities to vary the program would be limited. There was a good deal of discussion to determine whether centralization was required under the law. In this laboratory there is the minimum of centralization. A director with assistants maintains a central office, but the work of the laboratory is scattered. Thirteen states have designated a member of the technical staff of the respective stations to be a collaborator. Not all of the states were in position to cooperate actively by inclusion of a swine herd and land. However, there are now ten states which are actively cooperating in this manner. There has developed and is developing a satisfactory working coordination of the breeding program for swine in all of the states. Not all of the problems of coordination have been completely solved. Some of these remaining difficulties will be noted later, but no one has any fear that satisfactory answers will not be found.

The poultry disease laboratory at East Lansing is the result of a request jointly made by the directors of the Northeast and North Central Regions. It has a considerable amount of centralization, a resident staff, its own land and buildings; but a considerable amount of cooperative work is carried

on with certain stations. The laboratory at Auburn, Alabama, for the study of the diseases of livestock, is still more centralized, largely because of the nature of the work.

On the whole, the technique of cooperation provided by the Bankhead-Jones regional laboratories is proving satisfactory and is a pattern which may well be followed safely in other cooperative enterprises. In the opinion of many directors there should be established still other Bankhead-Jones regional laboratories. One additional has had the tentative approval of the directors of the Corn Belt and the Northeastern Region. It is believed that a coordinated attack should be made upon certain of the problems of breeding of dairy cattle. However, this cannot be done unless and until Congress reverses its attitude and appropriates to the U. S. Department of Agriculture all of the funds authorized under the Bankhead-Jones Act. Such a laboratory would probably perforce be one in which the actual work to be done would be widely distributed among the agricultural experiment stations. In my opinion, such additional regional laboratories will be provided whenever the members of the Society of Animal Production decide on what they want and become vocal about it. Furthermore, when the present regional laboratories were established it was intended that for each there would be provided additional funds from the future increments of the Secretary's Bankhead-Jones fund. These additions have not been forthcoming.

On the whole, I believe that the cooperative Bankhead-Jones laboratories are among the most promising of the adventures in state-federal relationships in research.

A word should also be devoted to the relationship of the four great regional laboratories established by the Congress to help solve the problems of the surpluses of agriculture, each with an initial investment of well over a million dollars, and each with an annual income of about a million dollars. Scarcely had they been established when war came; they have not been primarily working on the specific tasks originally assigned; they have had to take over some important war jobs. Problems relating to animal production have been assigned to the Philadelphia and to the San Francisco laboratories. Researches on stabilization of animal fats at the Philadelphia laboratory, and utilization of poultry products at Albany, California, are proving successful and important. These two laboratories have been quite cooperative, but the situation as related to war effort is somewhat abnormal. We in the experiment stations have not yet the relationships established with these laboratories that are needed in the long-run for the best possible cooperation. In the Congressional directive establishing these laboratories there is at one point a little word "at." The final interpretation of this word "at" will determine whether we will have real cooperation and an integra-

tion into a position of cooperation with our state agencies in agriculture, or the development of a competitive, relatively unrelated additional research laboratory. I believe that there will ultimately come the right relationship, and better cooperation in the solution of certain animal industry problems will be worked out. This is due to the fact that there is the will to cooperate.

The various aspects of animal industry research lend themselves somewhat differently to cooperation. Animal breeding requires large numbers of animals and considerable periods of time; research in this field would seem to require regional cooperation. It is evident that studies of this type will quite possibly be as significant in helping agriculture as have been the applications of genetics to the production of hybrid corn. However, there are some difficulties that should not be overlooked.

One practical problem is to clarify the understanding of breed association officers and breeders of purebreds with respect to improving swine further through breeding. The research in progress in the swine breeding laboratory suggests that need will probably arise for extending the service now provided by breed record associations. Indeed, the associations may need to enlarge their activities to designate inbred lines and guard their purity through procedures of registration.

The production of inbred lines is only purebreeding put into high gear. Therefore, under any plan for using inbred lines commercially, many purebred herds would be needed to produce and maintain inbred lines. If the breeders and their associations rise to this need, they should find opportunity for extending their service to the swine industry. But if they do not adjust their services to such needs, other means for the service must be found when results of the research make clear the services required.

Another difficulty in cooperation in animal breeding is the problem of disease. In some cases we are definitely attempting to breed for resistance to a specific disease, as fowl leucosis. But in most cases we are breeding for other desirable characteristics and attempting to ignore disease. It is my personal belief that an attempt to isolate or secure strains of hogs highly resistant to the several important swine diseases is highly desirable and should be developed on a regional or national basis. There is, for example, in the literature of swine husbandry enough evidence of natural immunity to several swine diseases to make it highly desirable that studies in this field be instituted. I do not believe with present funds and facilities this breeding for disease resistance in swine can be added to our present swine breeding program. It should have an independent but coordinated breeding setup. It needs to be done with the closest cooperation with qualified veterinarians.

One other point with reference to disease. Some day the public will wake up to the fact that millions of dollars spent on sewage disposal plants and

water purification systems have largely disposed of enteric diseases in man in many of our states. But literally we are doing absolutely nothing to prevent the transmission of swine diseases to man. Our records in Iowa show hundreds of cases of brucellosis in man each year, and with good evidence that the majority are of swine origin. Swine erysipelas is likewise transmissible to man. This is not a scare statement, but the situation is bad enough so that from the public health point of view some millions ought to be spent both in control of the disease and in breeding for disease resistance. Increasingly our experiment stations will be the agencies to which those who supply breeding stock to farmers will look for foundation stock. We dare not sell animals, even hogs, that are not free from disease. They must be sold on the basis of reasonable proof that they are not carriers. We need the more active and more intelligent use of the men in veterinary science, not the practicing veterinarian, but the expert pathologist and immunologist. There is far too much of an attempt to ignore disease implications on the part of our animal husbandry men and too much of professionalism on the part of our veterinary scientists. And both need to work with our public health agencies.

In the problems of management, physiology and nutrition, the need for regional cooperation is not quite so necessary as in breeding. Increase in knowledge in these fields does not usually require the coordinated use of large numbers of animals in different locations. This does not mean, however, that regional conferences are not highly desirable. One of the best types of federal-state cooperation would be to set up region by region a greater number of specialists' conferences in which representatives of the U.S.D.A. and the state stations could frankly discuss their problems, exchange ideas, and agree upon interstate cooperation where necessary. If it were possible to use specially appropriated federal funds for this purpose, it would be very helpful. In my opinion, there would ensue a great increase in appropriate integration.

Problems of marketing are especially satisfactorily approached upon a regional basis. Here in this North Central Region we have a regional committee consisting of men from animal husbandry and agricultural economics, with Director Johnson of South Dakota as chairman. A series of regional publications in this field is evidence of the validity of the technique. Another committee consisting of men in poultry husbandry and agricultural economics is at work, with Director Gardner as chairman, in the poultry marketing field.

In agriculture we are interested not only in the production of animals and their marketing, but the processing of these animals, their acceptability to the retailer and to the ultimate consumer, and their palatability and nutritional value. Regional and national cooperation is highly desirable in re-

searches in all of these fields. This is well illustrated in the studies in the development of dried eggs and similar products during the war, in which cooperation was initiated and stimulated by the Army. But the cooperators must be drawn from a large number of groups. *They must include the processors themselves, the research laboratories of the packers, the physiological chemists, the specialists in food, in nutrition, in experimental cookery, and in consumption economics.* We have some excellent beginnings, but we have not begun to do the whole job needed. Certainly, regular regional conferences, at least, are called for.

I have not in the course of this paper mentioned several increasingly important agencies which are markedly helpful in making for cooperation and coordination.

Our agricultural technical societies, such as this, should be emphasized. Your meetings, your committees, your resolutions and decisions play a major role in determining what is done or to be done. I am quite sure that in some cases you should directly memorialize the station directors of the several regions relative to the initiation of desirable cooperation.

The newly formed Agricultural Board of the National Research Council will take over several of the important national committees of the Council and will help to bring cooperation where needed on the national level, not only within agriculture, but with other agencies such as public health groups.

In summary, cooperation in animal husbandry research on regional and national bases is well underway. Cooperation is reasonably adequate in some areas; more is desirable in others. Many agencies other than animal husbandry are involved.

Those of you who have been in the office of the graduate dean at Iowa State College may remember a quotation which hangs on the wall. I would commend it to your consideration.

> Research is the earnest, purposeful, persistent, intelligently directed effort to gain new knowledge of a selected subject. The spirit of research is devotion to truth and insistent longing for better understanding.
>
> —ALFRED D. FLINN

May I add a paragraph.

> Cooperation in research is the fulfillment of a desire on the part of two or more individuals that through planning and working together there may be the maximum intelligent use of all available resources to the end that undesirable duplication in research be avoided, at the same time making sure that there are no serious gaps in coverage.

ACCOMPLISHMENTS OF THE REGIONAL ANIMAL RESEARCH LABORATORIES[1]

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ABSTRACT

The four regional animal research laboratories are: The Regional Animal Disease Laboratory at Auburn, Alabama; the Regional Poultry Research Laboratory at East Lansing, Michigan; the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa; and the Western Sheep Breeding Laboratory at Dubois, Idaho. The major objectives of all these research units include the discovery of new scientific facts and the application of known principles of science to the control of animal diseases and parasites and the breeding improvement of farm livestock.

Since their organization seven years ago progress has been steady and significant. This progress is measured in three ways: The creation of physical plant facilities and animal material to permit the conduct of productive research projects; the improvement in cooperative relationships among research workers in the regions; and a long list of tangible research results in each field of endeavor. Only progress of the latter type will be reviewed here.

The Regional Animal Disease Laboratory program has been confined largely to studies on Johne's disease, coccidiosis, and internal parasites of cattle. In the work on Johne's disease an important advance has been made in discovering methods to produce allergins of greatly increased potency. Using these biologics as diagnostic agents it has been learned by survey that a large percentage of the herds tested in a given area contain reactors. Three distinct types of infection were observed—characterized by emaciation and diarrhea terminating fatally, some loss in weight and occasional diarrhea with occasional fatal termination and positive pathological evidence of the disease but no clinical manifestation. Sensitization by the causative organism caused allergic response to mammalian tuberculosis in about 30 per cent of the cases, a point of considerable importance in connection with tuberculosis eradication programs.

The studies on coccidiosis have identified the species existent in the region, determined the time required for sporulation and developed procedures for diagnosis and estimating degree of infection. Coccidia are present in practically every herd in the area. A method of controlling clinical coccidiosis has been developed and is being put into practice.

The work on internal parasites has shown: What species are prevalent and which are most harmful to cattle in the southern States; that cattle tend to throw off an infection with common stomach worm at the same time developing marked resistance to further infection; and established the efficacy of phenothiazine for gastrointestinal roundworms. A mixture of salt and phenothiazine kept before grazing cattle is not an effective preventative against infection with these parasites.

The program of the Regional Research Laboratory for the Improvement of Viability in Poultry has been confined to a study of lymphomatosis in its various forms. Quarantine measures have been developed which are effective in keeping out common diseases and parasites but are not effective against lymphomatosis. Evidence has been obtained that the egg is an important factor in the transmission of the disease. It has been possible to develop free but susceptible stock through selection of families free of any clinical manifestations of the disease and the use of rigid pen quarantine measures under conditions of complete isolation. Also susceptible and resistant lines have been developed by breeding from stock on the basis of incidence of lymphomatosis. Studies on the causative agent have been limited by the slowness with which lymphomatosis develops. A related strain of the causative agent has been located

[1] This is one of three papers on cooperative animal research and regional laboratories, presented before the opening session of the annual meeting of the American Society of Animal Production, December 1, 1944. Only an abstract of this paper is presented, owing to the fact that most of the results cited have been published in detail in technical papers by workers at the various laboratories.

which has a shorter incubation period and gives a greater uniformity of reaction than material from lymphomatosis birds. The relationship of this tumor to lymphomatosis is now being studied.

The Regional Swine Breeding Laboratory has made very satisfactory progress on systems of breeding, measures for use in selection, the inheritance of characters and physiology of reproduction. In general some decline in fertility, survival and growth rates accompanies inbreeding but critical selection can prevent some of this. For growth rate, selection can offset the effect of inbreeding up to 15 percent per generation but fertility cannot be maintained without loss if the inbreeding is more than 4 percent per generation. It has been shown that purebred hogs can be inbred 3 to 4 percent per generation until about 30 percent is reached without much loss in productive characters if selection is critical. Individuals and lines this much inbred differ in many important physiological respects not discernible to the eye. Hybrid vigor can be expected from crossing lines within a breed if the lines are inbred 30 to 40 percent and are from unrelated foundations. The advantage shown is ½ more pigs per litter at birth, 1¾ more pigs per litter at 5 months of age and 30 pounds more live weight per pig at 5 months than the parent lines. Improvement of lines may be increased by using indexes based on number of pigs farrowed, weight and number of pigs at weaning, rate of growth to 5 or 6 months of age and a score for market desirability. The determination that variations in productivity of sows are 15 to 18 percent and variations in rate of growth to market weight are approximately ½ hereditary is important in connection with selection of breeding stock. Maximum rate of progress with respect to traits ¼ to ½ heritable will be made when at least ½ of the boar pigs are grown out to 5 or 6 months of age before final selections are made. If ¼ to ½ of the gilts are needed for breeding at least ⅔ of all gilts should be retained until 5 to 6 months of age.

The program of the Western Sheep Breeding Laboratory is coordinated with that of the U. S. Sheep Experiment Station and the progress to date includes certain accumulations of result material from previous efforts. Thirty lines of Rambouillet sheep are being purified for useful qualities by the use of inbreeding and critical selection. In general, the procedures being followed are similar to those used in the Regional Swine Breeding Laboratory. The speed of inbreeding is much slower with sheep than swine for practical reasons and the lines have not reached a degree of inbreeding yet which merits crossing of lines. It has been demonstrated, however, that the crossing of inbred lines of sheep results in measurable improvement. Progress is being made in breeding away from wool blindness. Open faced ewes at the laboratory produced about 9 pounds more lamb than the wool-blind ewes. Also it has been demonstrated that neck and body folds and wrinkles in Rambouillet sheep are useless monstrosities. Very significant progress has been made in their elimination from the laboratory sheep. As in the swine laboratory it is important to determine the heritability of the characters having economic value. For sheep the laboratory has determined that clean fleece weight has a heritability of 38 percent and fleece length 36 percent. Studies on small sample shrinkage have shown that this technique has a workable accuracy and holds great possibilities for field use in connection with shrinkage appraisals. In the studies on shrinkage involving 38,000 pounds of the 1943 laboratory clip, it was demonstrated that former commercial shrinkage appraisals have been too high.

Progress in large animal experimentation is inevitably slow, hence only a beginning has been made at the various laboratories in the few years since they were established. Physical plants are established and animal material is available. Improvement in cooperative relationships between institutions and workers and the output of tangible research results should continue to expand in the future.

ADVANTAGES AND LIMITATIONS OF THE REGIONAL LABORATORY METHOD OF APPROACH[1]

H. J. Reed
Purdue University

DURING the last few years we have witnessed what is probably the greatest demonstration in the world's history of organized research under the pressure of war necessity. The War Department has established several highly secret and efficient laboratories to solve many problems concerned with such problems as radar, chemistry, and bacteriology. The best available men from various parts of the country were brought into these laboratories and they have been welded into productive units that have contributed results of untold value to the war effort. Our success in this war is partly due to the fact that we are outstripping the enemy scientifically. The staffs in these laboratories have accepted their assigned places and have worked as teams with an enthusiasm and fervor that has amazed the country. They have their planning committees just as the Army has a general staff. Problems are analyzed, subdivided and assigned to various groups of specialists for solution. In due time the work of the groups results in greater fire power or an effective piece of equipment. This, in theory, at least, is comparable to the regional laboratory and the results would indicate that the idea is justified. They suggest many of the advantages of such institutions.

Some Advantages of Regional Laboratories

1. The regional laboratory enables workers to attack the many phases of a difficult, regional problem in a coordinated manner, with efficient use of available manpower, equipment, and facilities.

2. Care can be taken by the coordinating committee to see that all phases of the problem are worked on adequately, and to see that there are no gaps in the plan of attack. Let us look for a minute at an individual state station. Many of the problems confronting the experiment station are much larger in scope than a single subject-matter department, and demand the cooperative and coordinated efforts of several departments. The pasture problem, for example, involves agronomy, dairy, animal husbandry, agricultural chemistry, botany, and statistics. Specialists in each department can make an important contribution to the efficient production and use of nutritive grasses and forage crops. Likewise, the pasture problem of a region demands the best thought of the several state stations and the United States Department of Agriculture. Foreign importations and new strains produced in the various institutions can be tested widely to determine their

[1] One of a series of three papers on cooperative animal research and regional laboratories, presented before the opening session of the annual meeting of the American Society of Animal Production, December 1, 1944.

adaptability under many conditions. Grasses that might be thrown away in one state may prove valuable in another. The Regional Pasture Research Laboratory can pay handsome dividends to American agriculture. The Regional Swine Breeding Laboratory is another example of the pooling of talent and the facilities of the experiment stations and the United States Department of Agriculture on a problem that is too large for individual institutions to handle adequately. A group of competent men working together can generally see the problems and evaluate them better than an individual.

3. Conferences of workers and advisers, while the project is being written, are very important. Agreement can be had on the objectives and design of the experiments, and the methods of procedure can be carefully and scientifically worked out. Uniform methods and measurements are established, and a common philosophy developed which will aid immeasurably in determining the results. This will keep to a minimum unnecessary duplication, but will insure the amount of duplication that is desirable and necessary to assure that local conditions are not responsible for the differences observed.

4. It is desirable to have the acceptance of subprojects on a voluntary basis and for each worker to understand the relation of his subproject to the entire program.

5. Workers are benefited. Regional laboratories make it possible to give the specialists from the several institutions the stimulation that comes from an aggressive group working together under the leadership of a dynamic and inspiring director with his advisory committees. Results are more liable to be forthcoming because each individual will want to keep up his end of the load and merit the confidence of his co-workers. If each specialist who, as a member of the group on a regional project, gives his best to the project and to the committee discussions, he should certainly be lifted intellectually by having his thoughts tried in the crucible of scientific experience.

6. Risks are distributed. In problems involving large numbers of livestock, there is less danger of an epidemic destroying a project if the herds are located in several distant localities than if they were located at one central station.

7. It is quite possible that a few strains of animals would be developed with a definite genetic background and a known index of uniformity that would enable animal nutritionists, physiologists or others to get more positive results on the efficiency of rations, supplements, or what have you.

8. Ready acceptance of results. The fact that a number of qualified workers were involved in securing and interpeting the data should impress the public and scientific workers with its value and reliability. The prestige of the group would justify acceptance of facts and should speed adoption of recommendations.

9. Unity of purpose. Another advantage should be the development of greater unity of purpose among the workers and a maximum of coordination. Such activity should stimulate the completion of projects that have outlived their usefulness and the development of research programs of a higher order in our stations. New facts could be utilized in existing research, or in the interpretation of data.

10. Discouragement of pressure groups. If a research program has the sponsorship of the specialists of an entire region, it should be difficult for any group having a certain vested interest to bring enough pressure to force the discontinuance of an important project. It is not beyond the powers of our imagination to conceive a situation where a single station might be high-pressured, strong-armed, and forced to relinquish certain experiments.

11. Use of facilities. For some institutions, the Regional Laboratory provides the use of specialized personnel, such as statistical specialists who know how to sort out the significant data and make worthwhile analyses that might not otherwise be made.

12. It is probable that a more thorough going and comprehensive review of the literature will be made in a regional laboratory study before the research is undertaken than is often the case in a station project.

Limitations of This Method of Approach

My views regarding the limitations of the regional laboratory method of approach are perhaps colored by the fact that my experience has been confined to those laboratories working in the midwest, and by the fact that I have always viewed the problem from an experiment station point of view. In this area, I believe our regional laboratories are doing a good job and maintaining good relationships. This emphasizes, however, that two of the limitations are personnel and human nature. Without casting any reflections whatever on the directors of our regional laboratories, I want to make the observation that there is danger of making an unfortunate selection of the director of a regional laboratory, and the further probability that he will continue in office long after the mistake is detected. Leadership of the project is the job of the director and he is working with human beings, many of whom from a specialized, scientific point of view, are his superiors. Therefore, organizing ability, diplomacy and personality should be rated high in his qualifications. We should appreciate the fact that directing regional laboratories is a comparatively new job, and that personnel trained in the fine arts of this job were not available. The directors of these laboratories are pioneering and an effective procedure will evolve as we gain experience.

The director should be sufficiently far-sighted to guide the program in such a way that he can utilize and maintain the initiative of the workers, and at the same time, keep the program up-to-date and ready for new phases

as subprojects are completed. The director must be willing to sacrifice personal scientific glory to coordinate and lead a group in a long-time project.

A regional laboratory is a cooperative enterprise, and as such, requires men who can cooperate. And this suggests that more scientists must learn some lessons in human relationships before they can make their maximum contributions. *Prima Donnas* simply do not fit into such a scheme.

There is also the danger that the station personnel working on the project may become so regional-minded that important state problems would be overlooked. Also, in some cases, there might be a tendency to take the "edge" off the enthusiasm of some workers by requiring them to limit the scope of their activities, or by conforming to some generally accepted plan. Another disadvantage is that the publication of results would probably be slower; especially when federal agencies are involved. There is more reviewing necessary, more quibbling over commas and semicolons, more initials and more compromise.

The lag of time required to shift from one objective to another can be considered a limitation to the usefulness of the regional laboratory system. One or more cooperators who were behind schedule could easily prove to be a bottleneck and unless the director was ready with new phases of the program for those who had completed their work, stagnation would set in. This time lag, however, may also be regarded as an advantage because it assures farmers and breeders that there will be continuity to the research, and that the whims of an individual worker will not sacrifice some worthwhile research effort.

The value of the regional laboratory can be limited if its activities are too highly centralized. It is believed that the influence of station representatives should aid in giving breadth to the program.

Other Considerations

And now, I would like to make a few observations that cannot be classed either as advantages or disadvantages.

I think it is generally recognized that all problems are not suitable for study in regional laboratories, and if such programs were too common, they might detract interest from the purely local problem. One of the real difficulties is to determine how states can best fit into the regional laboratory approach. This is not an easy question to answer, for it means a rearrangement of station programs and to some extent, the rearrangement of the thinking of the men involved.

The individual collaborator should not feel that the job is his sole responsibility, but he should pass on to his associates on the station staff the thinking and the discussion that has been developed at the meeting of the collaborators, and solicit their suggestions.

In laying out a program for a regional laboratory, it is important that the immediate advisors and workers be brought together while the plans are still in the formative stage. These conferences can do a great deal of good and will eliminate a lot of misunderstanding. Additional meetings should be held whenever there are important results to consider.

The staff and cooperators should be called together to review results and discuss data when the project is nearing completion. This should preclude the possibility of printing a report which would be susceptible to serious misinterpretation, and would probably prevent any hostility between the principal author and his co-workers.

Conferences of workers and wise effort on the part of the director keeps the main objective of the research in the fore-front and enables the workers to understand each other's contributions more fully and consider their own results as a part of the solution of the basic problem.

I wish to quote a paragraph from a correspondent who prefers to remain anonymous: "I think it is important that each of the advisors do some work on the problem himself. If they meet merely as a board of advisors to listen and suggest, this does some good of course, but their advice is less sound and less keen, they will fail to see some of the opportunities and needs, they will not have as clear a picture of the possible defects in the work being reported, etc., as if each one were working himself on at least a part of the program. I think there is at present considerable variation among the regional laboratories as to how far this is fulfilled. Perhaps the swine laboratory goes as far as any of them in that direction and, even in this case, there are advisors not actively working on the topic. As I understand it, in some of the other laboratories only a little of the work is done away from the central station and most of the advisors are only advisors."

It is important that all concerned make every effort to preserve the independence of individual investigators and of the cooperating units.

Honesty and fairness of personnel must be maintained at a high level. Confidence of personnel in each other is essential to successful coordination. I think we all realize that some workers may be disturbed because other cooperators may be too aggressive. This difficulty can be obviated to some extent by fearless leadership on the part of the director. I believe that as the workers get used to working as teams, many difficulties will be eliminated.

We have all heard criticism of the regional laboratory idea by a few station men who feared that if the program was greatly enlarged, our agricultural research would be dominated by the bureaucrats in Washington. Frankly, I am not too concerned about that idea, because I believe that the so-called bureaucrats need the support of the state institutions. They have more to gain than they have to lose and in the second place, there are more workers

outside the bureaus than in them, and certainly equal in ability and leadership. I am much more concerned about the workers in the stations who have lost their initiative and are willing to continue with a mediocre program that has been "pumped dry." The truth of the matter is that the public has demonstrated its distaste for isolationists as well as dictators. More cooperative research will be carried on in the future. Agriculture may face problems after the war that will make such efforts imperative for the common good.

I think we should all realize that it is not necessary to have a regional laboratory to have regional research. This is demonstrated by the regional projects that are underway in the North Central region. The directors of this region decide upon the need for a regional study. One of the directors is asked to serve as a referee or leader; a technical committee is formed of specialists appointed by the directors and the work proceeds. Several important projects have been completed and reference can be made to the regional livestock marketing, the farm tenancy and the truck transportation studies as good beginnings in such cooperation. The results of these efforts have been published jointly by the cooperating stations and are additional evidence of the value of the cooperative approach to important problems that affect a large area of the country. The slowness of our state stations to appreciate the value of, and to undertake cooperative research on regional problems, may have accounted for the fact that Congress saw fit to establish regional laboratories for specific problems. These institutions now provide a challenge to research workers to make their work most effective. We are learning how to cooperate beyond the boundary lines of the state to conquer the plagues of the plant and the animal industries and some of the economic problems that know no state lines or artificial divisions of science.

The public is convinced that research is the magic wand that can remove the barriers of the unknown and enrich our land and our lives. John Q. Public "puts the cash on the barrel head" and he wants results. If our experiment stations fail to meet the needs of the times, he will make other arrangements. I have unbounded confidence in our experiment stations and research laboratories but we must have teamwork. The great business corporations were created to accomplish things that small business men could not do. Cooperatives were developed to handle problems too big for the individual. And while occasionally a scientific David will kill a Goliath, our great progress will depend on a well organized and coordinated offensive. We should keep in mind that there is no substitute for results.

Agriculture faces a difficult future. The key to the solution is an aggressive research program that overwhelms problems that seem insurmountable.

THE INFLUENCE OF LOCATION AND SIZE OF SAMPLE IN PREDICTING WHOLE-FLEECE CLEAN YIELDS

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THE amount of clean wool produced by individual sheep is of primary importance in breeding for greater wool production. Scouring whole fleeces requires considerable equipment, labor and time; hence laboratory techniques for scouring wool samples of 200–250 gms. were developed by Spencer *et al.* (1928), Wilson (1928), Burns (1930), and Hardy (1934). Davis *et al.* (1938) and Schott *et al.* (1942) reported that smaller samples of wool (25–35 gms.) from the shoulder and side, respectively, gave accurate estimates of the clean yields of whole fleeces. Pohle, Wolf and Terrill (1943) and Pohle and Hazel (1944) investigated clean yield in 8 different parts of the fleece in an attempt to determine the most accurate sampling locations. Differences in average clean yields of the various parts were clearly evident and locations along the topline (withers, back and rump) gave less accurate estimates of clean yield in whole fleeces than the remaining locations.

In the present study, half-fleeces were separated into a predetermined number of small samples in order to compare clean yield of the various samples with that of the intact half-fleece. Gradients in clean yield and accuracy which are not otherwise discernible were revealed by this method. In addition, the influence of sample size upon accuracy was studied experimentally by combining small samples into larger groups.

Materials and Methods

There were 40 yearling range ewe fleeces used in the study, 10 each from the Rambouillet (fine wool) and Columbia ($\frac{3}{8}$ and $\frac{1}{4}$ Blood wool) breeds in 1942 and 1943. The ewes were born during April and May of 1941 and 1942 and were grazed on the range the entire year except for about four months during the winter feed-lot period. They were sheared by a commercial shearer with electric clippers the last week in May each year.

Ten ewes were selected at random from a total of 275 Rambouillets and 80 Columbias each year. Six major regions were outlined on the right side of each sheep with colored chalk before shearing to facilitate greater accuracy when separating the fleece. Each fleece was laid out on a sorting table and split down the back. The left half was kept intact for scouring. The right half was first split into the six major regions and the wool from each region was subdivided into the following number of small samples of approximately 35 grams each, according to its position on the body: Neck, 10; shoulder, 8; side, 12; back, 8; breech, 12; and belly, 6. This scheme is illustrated in figure 1. The wool samples were stored in properly marked air-tight cans until

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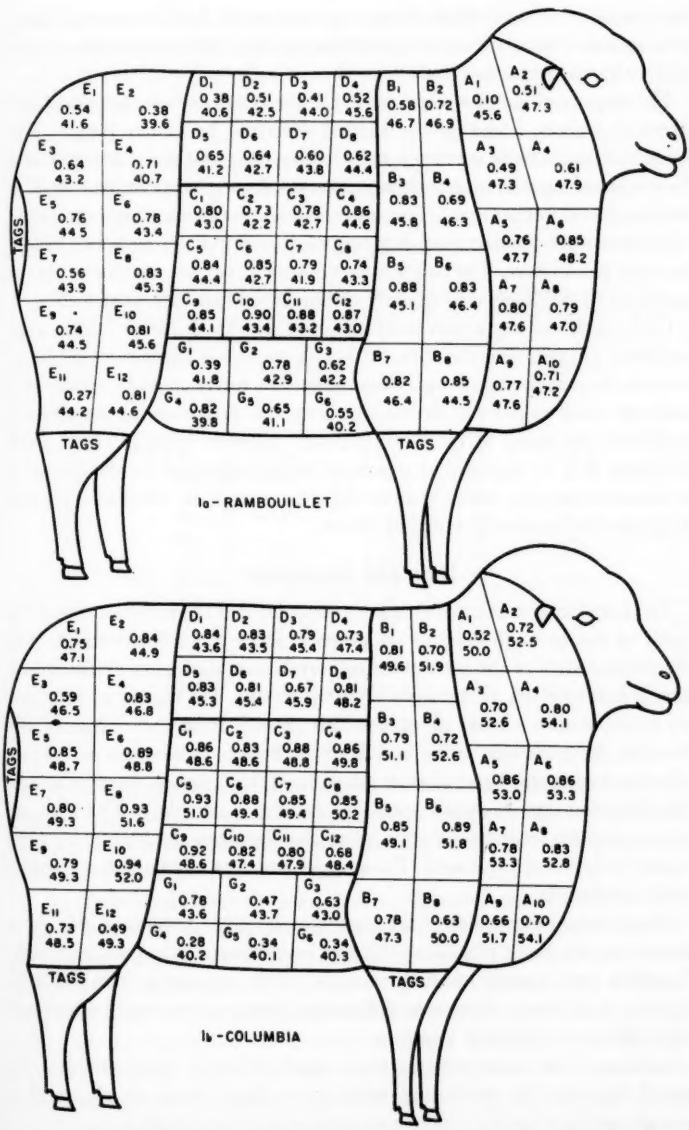

Figure 1. The sketches show the anatomical location of the 6 major regions and the areas within each region. The regions are designated by letters and the areas by subscripts. The first value within each area is the correlation coefficient between the clean yield of the area and that of the intact half-fleece, while the second value is the bone-dry clean yield in percentage for the area.

they could be scoured. Half of the tags and sweat locks from each fleece were included with the intact half-fleece and the remainder made up the tag sort for the zoned half-fleece.

The 2240 small samples were scoured in the Bureau's wool scouring laboratory at Dubois, Idaho by the method described by Hardy (1934). The intact half-fleeces were separated into portions weighing about 200 gms. and these were scoured by an emulsion process similar to that described by Wilson (1928) and Burns (1930). The small samples and check samples from the half-fleeces were dried in a conditioning oven at 212° F. for six hours to free the wool of moisture. The half-fleeces were corrected for moisture content and all clean yields are subsequently referred to as bone-dry wool yields.

Correlation and regression analyses as outlined by Snedecor (1940) were employed in examining the data. Although statistical significance of differences in the correlation or regression coefficients rarely could be established with the small number of fleeces involved, the design of the experiment permitted the study of trends within and between breeds. Thus, small variations may be regarded as significant when supported by the evidence of adjacent samples, while obvious departures from an otherwise general trend may be regarded as sampling errors.

Data and Discussion

The correlation coefficients between clean yield of the half-fleeces and the yields of the 56 small samples are given in figure 1 for Rambouillets and Columbias. Most of the corresponding correlations are higher in Columbias than in Rambouillets, particularly along the topline. The highest correlations are found within a band of wool which extends from the middle of the shoulder along the side to the middle of the breech. Differences in the correlations within this band of wool are so small that further choice of a sampling location may be based upon convenience in sampling. The least accurate sampling locations lie adjacent to the outline of the body, along the topline belly, breech and neck. These trends are very regular and are similar in the two breeds.

The average clean yields of the small samples given in figure 1 also show distinct trends, being highest on the neck and lowest on the back and belly. Therefore small samples must be taken as nearly as possible from the same location on all sheep; otherwise, differences between sheep will be confused with differences between locations.

Because of the experimental errors associated with small samples, the logical equation for predicting whole-fleece yield from sample yield is $X=\frac{Y-a}{b_{y\cdot x}}$, where Y is the observed sample yield and X the whole-fleece

yield to be predicted. The 56 regressions of sample yield on half-fleece yield were calculated for both Rambouillets and Columbias. The average of the 56 coefficients was 0.97 percent for Rambouillets and 1.08 percent for Columbias. These averages approach the theoretical value of unity expected for thoroughly sampled fleeces. The individual regressions varied considerably among themselves, exhibiting regular changes from one anatomical location to another which were similar for the two breeds. The regressions from the side were highest while those from the belly, back and top of the shoulder (withers) were lowest. This indicates that variations in the clean yield of

TABLE 1. CORRELATION AND REGRESSION COEFFICIENTS FOR WHOLE-FLEECE AND SMALL-SAMPLE YIELDS OF THE SIDE REGION

Small sample location	Rambouillet			Columbia		
	r	a	$b_{y.x}$	r	a	$b_{y.x}$
C_1	0.85	−12.7	1.26	0.89	−19.6	1.40
C_2	.79	− 3.6	1.04	.84	−12.7	1.26
C_3	.84	− 5.3	1.08	.90	−19.3	1.40
C_4	.90	−11.2	1.26	.90	−12.7	1.29
C_5	.89	− 3.5	1.08	.94	−10.7	1.27
C_6	.89	+ 1.3	0.94	.83	−13.9	1.30
C_7	.82	+ 0.5	0.94	.88	−19.8	1.42
C_8	.75	− 1.3	1.01	.90	−15.6	1.36
C_9	.87	− 1.3	1.03	.91	−15.9	1.33
C_{10}	.89	− 1.5	1.02	.85	− 7.9	1.14
C_{11}	.87	− 0.5	0.99	.83	−13.5	1.26
C_{12}	.89	− 1.6	1.01	.73	−15.4	1.31
Average	.85	− 3.4	1.05	.87	−14.8	1.32

whole fleeces are reflected unevenly in the wool from different parts of the body. Therefore, correct regression coefficients for predicting whole-fleece yield from small-sample yield must depend upon the particular location from which the small samples are taken.

The sample yields for the side (C_1–C_{12} in figure 1) were selected for further study because these locations are among the most accurate and are easy to sample on the live animal. The correlations, a and $b_{y.x}$ coefficients for whole-fleece yields and small-sample yields are given in table 1. The correlations between small-sample yields and whole-fleece yields are about .02 higher than the corresponding correlations involving half-fleece yields shown in figure 1. The $b_{y.x}$ values are rather consistently greater than unity for both Rambouillets and Columbias. This is in accord with the 1.01 and 1.11 percent given by Schott *et al.* (1942) and with the 1.19 and 1.45 percent given by Pohle and Hazel (1944) for the regression of side-sample yield on whole-fleece yield for Rambouillets and Columbias respectively. The influence of

yearly variations in dirt, grease and moisture and of geographical and climatic factors must be investigated more thoroughly before general conclusions can be reached concerning the magnitude of the $b_{y \cdot z}$ values. However, the evidence accumulated thus far indicates that the regresison of small-sample yield from the side on whole-fleece yield is greater than unity in each breed.

Measurements of the skin area encompassed by each of the 6 major regions showed that the belly and back produce the smallest amounts of clean wool per unit skin area. Length of staple measurements on the various small samples showed that the wool from these locations is shortest in length while that from the side and lower thigh is longest. The clean yield values in figure 1 are lowest for the belly and back. The predictive value of small samples and

TABLE 2. ANALYSIS OF VARIANCE FOR SMALL-SAMPLE CLEAN YIELDS

Source of variation	Degrees of freedom	Rambouillet			Columbia		
		Mean square	F	Component	Mean square	F	Component
Total	1,119	25.1	—	—	34.9	—	—
Regions	5	815.0	6.78*	—	2199.2	35.74**	—
Years	1	5315.4	11.50*	—	225.8	—	—
Regions×years	5	100.1	2.95	—	53.5	1.49	—
Sheep	18	454.9	17.14**	7.65	840.1	30.08**	15.50
Sheep×regions	90	26.5	4.54**	2.22	27.9	3.79**	2.20
Areas	50	33.3	2.51**	1.00	50.3	3.27**	1.74
Years×areas	50	13.3	2.27**	0.74	15.4	2.09**	0.80
Sheep×areas	900	5.85	—	5.85	7.36	—	7.36

* $P < .05$.
** $P < .01$.

the magnitude of the $b_{y \cdot z}$ values appear to be associated with the amount of wool per unit area, length of staple and anatomical location on the body.

The analysis of variance for the small-sample data is shown in table 2. Differences between regions and between sheep are much larger in Columbias than in Rambouillets while differences between years are more noticeable in the latter breed. The interaction sheep x regions is highly significant in both cases, implying that the general gradient shown in figure 1 is not duplicated exactly in all fleeces. The highly significant interaction years x areas shows that grease, dirt and moisture are not present in the same areas in exactly the same relative proportions in different years. It is not surprising that these interactions exist in view of the many climatic and biological factors which may influence the deposition of grease, moisture and dirt in various parts of the fleece. They are not large; otherwise serious limitations would be imposed upon the accuracy of small samples, particularly if the samples were taken from only one location.

An important problem in sampling for clean yield is that of sample size. The effect of sample size upon accuracy of the clean yield was studied in three ways. First, theoretical correlations were derived from the components of variance given in table 2. The covariance expected between small-sample yield and whole-fleece yield for Rambouillets is the component of variance between sheep, 7.65. The expected variance for whole-fleece yield is also 7.65 while that for sample yield is

$$\frac{5.85}{nk} + \frac{2.22}{k} + 7.65,$$

where n is the number of small samples per region and k is the number of regions sampled. Thus the expected correlations given in table 3 were calculated from the formulas,

$$r = \sqrt{\frac{7.65}{\frac{5.85}{nk} + \frac{2.22}{k} + 7.65}} \quad \text{and} \quad r = \sqrt{\frac{15.50}{\frac{7.36}{nk} + \frac{2.20}{k} + 15.50}}$$

for Rambouillets and Columbias, respectively.

Second, the effect of sample size upon accuracy was studied by calculating correlations between half-fleece yield and the average yields of the 56 small samples combined as follows: (1) individual small samples; (2) two adjacent small samples; (3) all samples in each of the 6 major body regions; (4) all in two adjacent regions; (5) all in three adjacent regions and (6) all in the 6 regions of the half-fleece. Thus, the number of correlations calculated and averaged was 56, 28, 6, 3, 2, and 1, respectively. The actual correlations were averaged by Fisher's (1936) Z method.

The theoretical and actual correlations given in table 3 increase with sample size, although the rate of increase becomes progressively smaller as

TABLE 3. THEORETICAL AND ACTUAL CORRELATIONS AS INFLUENCED BY SIZE OF SAMPLE

Number of samples per region	Number of regions	Grease weight of total sample	Theoretical correlations		Actual correlations	
			Rambouillet	Columbia	Rambouillet	Columbia
		grams				
1	1	35	0.70	0.79	0.73	0.79
2	1	70	.77	.85	.78	.84
9.33	1	325	.85	.92	.82	.90
18.67	2	650	.92	.96	.89	.94
28	3	980	.94	.97	.90	.95
56	6	1960	.97	.98	.91	.96

the size of sample increases. The theoretical correlations increase more rapidly than the actual correlations because half-fleece yield was used as one variable in calculating the latter. With large sample size, even relatively small experimental errors in the half-fleece yields become important in limiting the magnitude of the correlations.

Third, correlations between whole-fleece yield and the yields from several combinations of small samples from the side were calculated (table 4). These

TABLE 4. CORRELATIONS BETWEEN WHOLE-FLEECE YIELD AND YIELDS FROM THE SIDE REGION AND STANDARD ERRORS OF ESTIMATE AS INFLUENCED BY SIZE OF SAMPLE

No. of small samples	Grease weight of total sample	Correlation coefficient		Standard error of estimate	
		Rambouillet	Columbia	Rambouillet	Columbia
	grams			*percent*	*percent*
1	35	0.855	0.866	1.84	2.05
2	70	.887	.892	1.58	1.81
4	140	.907	.914	1.40	1.58
6	210	.919	.929	1.30	1.42
12	420	.942	.952	1.08	1.15

show the increase in accuracy due to sampling only the most accurate locations in addition to the gain due to larger sample size. They are perhaps more representative of the increased accuracy which accompanies large samples than those given in table 3 since it is logical that samples be taken from the most accurate region. The difference between the predicted clean yield and the true whole-fleece yield should be within one standard error of estimate of the whole-fleece yield in about two-thirds of the cases. The standard error of estimate for 420-gm. samples is from 40 to 45 percent smaller than that for 35-gm. samples. Where the actual bone-dry clean yield of a Rambouillet fleece is 40.0 percent and the grease-fleece weight 10 pounds, the clean wool would weigh 4.00 pounds. If a 35-gm. sample were taken from the side the predicted clean weight would be between 3.82 and 4.18 pounds in 68 percent of the cases and would fall outside the limits 3.63 and 4.37 pounds only 5 percent of the time. On the other hand, if a 420-gm. sample were taken, the corresponding limits would be from 3.89 to 4.11 pounds and from 3.78 to 4.22 pounds, respectively.

When sample yields are used to predict whole-fleece yields (the independent variable), the standard deviation of the predicted values is σ_x/r_{xy}, where σ_x is the standard deviation of the actual whole-fleece yields and r_{xy} is the correlation coefficient between whole-fleece yield and sample yield. The standard error of estimate is

$$\frac{\sigma_x\sqrt{1 - r_{xy}^2}}{r_{xy}},$$

greater by $1/r_{xy}$ than where a dependent variable is predicted from an independent variable.

Summary and Conclusions

Fleeces of 20 Rambouillet and 20 Columbia yearling ewes were halved, one half being scoured intact and the other half being separated in 56 small samples of approximately 35 gms. each before scouring.

Correlations between clean yield of the half-fleece and the 56 small-sample yields showed that the most accurate sampling locations were on the side and on the shoulder and breech adjacent to the side. The correlations involving back and belly samples were noticeably lower than those involving other locations. Samples from the side of the neck and shoulder were highest in clean yield while those from the back and belly were lowest. Samples from the side of the back and shoulder were highest in clean yield and in the amounts of clean wool per unit skin area while those from the back and belly were lowest in those respects.

The average regression coefficients of the 56 sample yields on half-fleece yield were 0.97 and 1.08 percent for Rambouillets and Columbias, respectively. The individual regressions varied considerably, being lowest on the belly and back and highest on the side. Therefore the correct regression coefficient for predicting whole-fleece yield from small-sample yield depends upon the location from which the samples are taken.

Correlations between whole-fleece yield and the yields of 35-gm. samples taken from the side averaged .85 for Rambouillets and .87 for Columbias. The regressions of small-sample yields from the side on whole-fleece yields averaged 1.05 for Rambouillets and 1.32 for Columbias.

The influence of sample size upon accuracy of sample yield was studied in three ways: first, by deriving theoretical correlations expected between whole-fleece yield and samples of varying size; second, by combining the 56 small-sample yields into larger groups and calculating correlations between these and half-fleece yield, and third, by combining the 12 small-sample yields from the side in several ways and calculating correlations between these and whole-fleece yield. While accuracy of sample yield can be increased by taking samples larger than 35 gms., the rate of increase becomes progressively smaller as the size of sample increases. The location of the sample is fully as important as the size of sample.

Wool technicians stand to gain many advantages by adopting uniform techniques, particularly where those techniques may have commercial ap-

plication. The adoption of a standard sampling location seems especially advisable because the same general trend in clean yield and in accuracy throughout the fleece appears to hold for breeds differing widely in fineness and in staple length. The middle of the side is suggested for this purpose because it is centrally located within the most accurate region and samples can be taken there conveniently. Standardization of the equation for predicting whole-fleece yields from sample yields perhaps will not be possible. The investigations completed to date do not include a very large sample of years, breeds, geographical locations or systems of management; hence, it is not possible to determine whether the *a* and *b* values remain constant. The standardization of sample size is advisable only for routine operations where extreme accuracy is not required. For example, samples weighing 35 gms. are adequate for use in a breeding program where the clean yield of many fleeces must be predicted but samples of 150 to 200 gms. may not provide the accuracy required for rigorous experimental investigations.

Literature Cited

Burns, Robert H. 1930. Wool Shrinkage Determination by Means of Small Samples. Amer. Soc. Animal Prod., Proc., pp. 196–203.

Davis, S. P., J. M. Jones and B. L. Warwick. 1938. Accuracy of Small Wool Samples for Shrinkage Tests. Texas Agr. Exp. Sta. Fifty-first annual report of the director, pp. 39–40.

Fisher, R. A. 1936. Statistical Methods for Research Workers. Sixth Edition, 339 pages. Oliver and Boyd, Edinburgh and London.

Hardy, J. I. 1934. Wool Yield and Fleece Density Can Be Measured by a Simplified Method. USDA Yearbook, p. 378.

Pohle, E. M., H. W. Wolf and C. E. Terrill. 1943. Clean Wool Yield Variation Among Regions of Rambouillet Fleeces. JOURNAL OF ANIMAL SCIENCE, 2: 181–187.

Pohle, E. M. and L. N. Hazel. 1944. Clean-Wool Yields in Small Samples from Eight Body Regions as Related to Whole-Fleece Yields in Four Breeds of Sheep. JOURNAL OF ANIMAL SCIENCE, 3: 159–165.

Schott, R. G., E. M. Pohle, D. A. Spencer and G. W. Brier. 1942. Wool Yields in the Small Side-Sample as Related to Individual Whole-Fleece Yields in Four Breed-Groups of Sheep. JOURNAL OF ANIMAL SCIENCE, 1: 137–144.

Snedecor, G. W. 1940. Statistical Methods. Third Edition, 422 pages. The Iowa State College Press, Ames, Iowa.

Spencer, D. A., J. I. Hardy and Mary J. Brandon. 1928. Factors that Influence Wool Production with Range Rambouillet Sheep. USDA Tech. Bull. 85, 48 p., illus.

Wilson, J. F. 1928. A Method of Determining the Clean Weights of Individual Fleeces of Wool. Calif. Agr. Exp. Sta. Bull. 447, 21 p. illus.

SAMPLING WOOL CLIPS FOR CLEAN YIELD BY THE CORE BORING METHOD[1]

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THE commercial value of a wool clip is directly related within each grade to the pounds of clean wool it will yield after scouring. The difference between the weight of grease wool is determined by varying amounts of grease, dirt, excreta, moisture, and extraneous matter contained in the grease wool. Yield of clean wool is expressed as a percentage of the grease wool while "shrinkage" is that part of the grease wool which is removable by scouring as expressed in terms of percentage of the grease wool.

Grease wool is commonly sold on the basis of its probable content of clean wool as estimated by its visual appearance and handling qualities. The accuracy of this method of appraisal is subject to the errors of human judgment, which undoubtedly may be of considerable importance both to the buyers and sellers of wool.

A method for the estimation of wool shrinkage which is free of human bias and still accurate would be a great aid in bringing about a more equitable distribution of wool returns to producers and would be of importance to the textile industry as a whole.

There are many difficulties attendant upon the accurate sampling of grease wool that are due mainly to the heterogeneity of the material and also to the method by which wool is commonly packaged for shipment. The feasibility of employing small samples to represent bulk shrinkage has been discussed by Burns (1938), Wilson (1938), and Esplin, Phillips, and Madsen (1941).

Wollner and Tanner (1941) used a special constructed core boring device for sampling imported baled wool. The equipment consisted of a metal tube 16 inches long and 2 inches in diameter, provided at one end with cutting edges and driven by an electric motor. Core samples were taken at random from each bale of wool. They reported that the error of shrinkage estimates based on the mean of 100 cores had a probability of only .05 of exceeding ½ of 1 percent for Australian and South American wools.

This study was undertaken to determine the nature and the amount of variation in shrinkage present within a bagged wool clip employing the core

[1] Paper No. 139 Scientific Journal Series of the Montana Agricultural Experiment Station.

[2] This study is based on data obtained through researches conducted by the Wool Division, Livestock and Meats Branch, Office of Distribution, War Food Administration, in cooperation with the Montana Agricultural Experiment Station. Special thanks are due Mr. Alexander Johnston, formerly field supervisor in charge of coring work at the time these data were collected, and now Chief of the Wool Division, Mr. Warner M. Buck, Marketing Specialist, Mr. George LeCompte, Marketing Specialist, who conducted the laboratory determinations on shrinkage of sample cores, all of the Wool Division, Livestock and Meats Branch, Office of Distribution, War Food Administration, and to Mr. Curtis Hughes, formerly wool specialist at the Montana Agricultural Experiment Station, who assisted in the collection of the data.

boring method of Wollner and Tanner (1941) and to estimate the size of sample necessary to represent the shrinkage within specified limits of error.

Material and Methods

The data consist of grease and scoured weights of 264 individual cores taken from 95 bags of graded wool. This represents the 1943 wool clip of the Montana Agricultural Experiment Station which included about 2700 fleeces. From each bag 3 cores were taken at random.[3]

The region of the bag to be sampled was first compressed with a special compression device by which extraction of the core was facilitated. Each core was weighed to the nearest ½ gram and sealed in a paper bag. The samples were scoured in the laboratories of the Wool Division, Livestock and Meats Branch, of the War Food Administration.

Snedecor's (1940) methods of statistical analysis were used for treatment of the data.

Results

The number of bags and cores, average grease weights, and average clean yield of cores by yearling and aged ewes is given in table 1. Grease weight

TABLE 1. AVERAGE CLEAN WOOL YIELDS OF DIFFERENT GRADES OF WOOL

Type of ewe	Grade	Bags	Cores	Ave. grease wt.	Ave. clean wool yield*
		number	*number*	*grams*	*percent*
Aged ewes (2 or more years of age)	Fine French	8	20	101	50.8
	Fine staple	19	52	109	52.8
	½ staple	27	78	103	54.7
	⅜ staple	17	46	95	57.8
	¼ staple	4	11	99	59.6
Totals and averages		75	207	102	54.8
Yearling ewes	Fine staple	5	13	95	51.5
	½ staple	9	27	101	51.0
	⅜ staple	5	14	98	53.3
	¼ staple	1	3	115	59.5
Totals and averages		20	57	100	52.1

* Not corrected for rescouring factor.

of cores does not appear to be influenced by grade. The aged ewe wools show slightly higher clean wool yield than the yearling wools with an average difference of 2.7 percent.

[3] This was accomplished by dividing each bag into 7 areas. The particular areas to be sampled were then chosen by a system of random numbers.

Table 2 contains an analysis of variance of the data grouped according to age of ewes, grades within ages, bags within grades, and cores within bags. The age group difference appears to be significant, but no exact test was made.[4] Grade differences are highly significant. The variance for bags within grades is about the same magnitude as the variance within bags. Evidently, all of the variance within grades is accounted for by the variance within bags. A better estimate of the intra-grade variance would be obtained, therefore, by ignoring bag differences and taking the variance directly between cores within grades which would increase the degrees of freedom from 169 to 225 for this variance.

TABLE 2. ANALYSIS OF VARIANCE OF CLEAN WOOL YIELDS

Source of variance	d/f	Sum of squares	Mean squares
Age groups	1	314.7	314.7
Grades within age	7	1402.9	200.4*
Bags within grades	86	2225.4	25.9
Cores within bags	169	4543.5	26.9
Total	263	8486.5	32.3

* $P < .01$.

From an estimage of shrinkage variance, the number of cores, (N), necessary for any level of accuracy may be calculated from the following formula:

$$N = \frac{t^2\sigma^2}{E^2} \qquad (1)$$

where:

t = probability factor which is equal to 1.96 when $p = .05$.

σ^2 = shrinkage variance.

E = sampling error.

The reliability of derived values of N depends on the accuracy of the estimate of σ^2, which may be chosen to represent the intra-grade variance, σ_w^2, or the intra-lot variance, σ_p^2. σ_w^2 is appropriate for wools that are sorted into grades while σ_p^2 is appropriate for ungraded lots of wool. When σ_w^2 is a "pooled" variance representing a "best estimate" applicable to all grades it is strictly valid only when the variances within the several grades making up the pooled estimates are homogeneous. It seemed advisable, therefore, to test first the homogeneity of the intra-grade variances.

Table 3 contains the variance in clean yield according to grade of wool and age of ewes. A test of the homogeneity of variance for different grades of ewe wool yielded a $X^2 = 12.7$ which, with 4 degrees of freedom between grades, is significant ($P < .05$). Apparently the $\frac{1}{4}$ blood variance is greater than that found in the other grades of ewe wool. On the remainder of the

[4] This is because subclass numbers (grades at each age) were disproportionate.

ewe wools a $X^2 = 1.8$ was obtained which is not significant and indicates that the variance within these grades is homogeneous. A $X^2 = 5.0$ was obtained for the intra-grade variances of the yearling ewe wool. Since this is not significant for 3 degrees of freedom these variances may be assumed to be homogeneous. However, the pooled intra-grade yearling wool variance is evidently smaller than that for the ewe wools as shown by a $X^2 = 14.7$ which is significant for $P < .01$ with one degree of freedom. One might suspect this as a result of the comparatively large $\frac{1}{4}$ blood variance contained in the ewe wool which has already been shown to be significantly different from the other ewe grade variances. However, even when the $\frac{1}{4}$ blood grade is omitted from the analysis, a $X^2 = 11.5$ is obtained which is still highly significant with one degree of freedom.

TABLE 3. THE VARIANCE IN CLEAN YIELD OF WOOLS BY DIFFERENT GRADES

Grade of wool	Ewe wool		Yrlg. ewe wool	
	d/f	σ^2	d/f	σ^2
Fine French	19	35.99	—	—
Fine staple	51	22.44	12	8.00
$\frac{1}{2}$ staple	77	26.45	26	8.76
$\frac{3}{8}$ staple	45	29.34	13	22.03
$\frac{1}{4}$ staple	10	94.61	2	13.91
Within grades	202	30.35	53	12.04

The results indicate 3 types of variances as determined by tests of homogeneity. First, aged ewe wool appears to be more variable than the yearling wool. Second, within the aged ewe wool, the $\frac{1}{4}$ blood grade appears to be more variable than the other grades. The first is explainable since the older ewes and yearlings were handled in separate bands and therefore may have been subject to different environmental influences. The second, however, is difficult to explain. It is felt that more data would be desirable before one should conclude beyond reasonable doubt that the $\frac{1}{4}$ blood grade is more variable than the other grades of ewe wool.

It appears that separate estimates of variance are appropriate for estimating the number of cores necessary to represent the aged ewe wool and the yearling wool. Table 4 contains analyses of variance of the ewe wool and the yearling wool, separately.

The pooled variances (σ_w^2) are equal to 30.35 and 12.04 for the former and the latter, respectively. Since the aged ewe intra-grade variances were shown by X^2 test to be non-homogeneous, the estimate of 30.35 is not strictly valid. Snedecor (1940) gives a method of overcoming this difficulty by calculating a weighted average variance. In this case the weights would be pro-

TABLE 4. ANALYSES OF VARIANCE OF AGED AND YEARLING EWE WOOLS

Source of variance	Aged ewe wool		Yearling ewe wool		Theoretical composition of mean squares
	d/f	Mean squares	d/f	Mean squares	
Between grades	4	294.74*	3	74.65*	$\sigma w^2 + k_0 \sigma_b^{2a}$
Within grades	202	30.35	53	12.04	σw^2
Total	206	35.49	56	15.39	

* $P < .01$.

[a] k_0 = the average number of cores per grade, $\bar{k}$ corrected for the variance in mean number of cores per grade, Vk/n. Symbolically, $k_0 = \bar{k} - Vk/n$. σb^2 is equal to 6.97 and 4.99 for the ewe wool and yearling wool respectively.

portional to the total weight of each grade in the entire lot. Employing this method, a value of 30.00 is obtained for the weighted average variance.[5] This does not differ greatly from the pooled estimate of variance, since the degrees of freedom of the grade samples are in very nearly the same proportions as the bulk weights of the grades.

Referring to formula (1) the number of cores required to represent a lot of wool within specified limits of error can be calculated from the estimates of σ^2 obtained. Table 5 contains the estimated number of cores of ewe

TABLE 5. THE NUMBER OF CORES REQUIRED TO REPRESENT A LOT OF GRADED WOOL WITHIN A SPECIFIED SAMPLING ERROR

Item	Accuracy, in percent*			σ^2
	2	1½	1	
Number of cores of aged ewe wool	29	51	115	30
Number of cores of yearling ewe wool	12	21	46	12.04

* $P = .05$.

wool and yearling wool of which the means would not be expected to exceed the true mean by more than 2, 1.5, and 1 percent with a probability of .05. It is evident that over twice as many cores of ewe wool as of yearling wool are required for equal levels of accuracy. About 29 cores of ewe wool are required for an accuracy within 2 percent while almost four times this number, or 115, are required for an accuracy of 1 percent. For the yearling wool, 12 and 46 cores are required for accuracies of 2 and 1 percent, respectively.

Since these wools were graded before extracting samples, it will be of interest to estimate the loss in accuracy which would have resulted had the

[5] The formula may be written $S w_i \sigma_i^2$ where w_i is equal to the fraction of the total lot of wool included in the ith grade and σ_i^2 is equal to the variance in the ith grade.

wool not been graded and had samples been taken purely at random. This may be accomplished by obtaining an unbiased estimate of the population variance (σ_p^2) for each of the two lots of wool and comparing these with the corresponding intra-grade variances. The total variances given in table 4 are inappropriate as estimates of population variances since they are larger than random variance due to the restrictions imposed in sampling this particular population. However, the analysis of variance contained in this table may be used for obtaining an estimate of the population variance. The method is indicated by the approximate formula:[6]

$$\sigma^2 b(1 - Sw_i^2) + S(w_i\sigma_i^2)$$

where:

$\sigma^2 b$ = variance component due to differences between grades (see table 4),

and where w_i and σ_i^2 refer to the same quantities as given in footnote 5. This method yielded estimates of σ_p^2 equal to 35.14 and 14.90 for the ewe and yearling wools, respectively. When samples are obtained from ungraded ewe wool, the loss in accuracy is:

$$100\left(\frac{35.14 - 30.00}{30.00}\right) = 17\%.$$

Similarly, when the yearling wool is not graded, the loss in accuracy is:

$$100\left(\frac{14.90 - 12.04}{12.04}\right) = 24\%.$$

This means that about 17 percent and 24 percent larger samples of ungraded than graded ewe and yearling wool, respectively, would be required for the same degree of accuracy.

The variances reported for the several grades of wool were calculated from individual cores which differed by as much as 80 grams of grease weight within some grades. One would expect the error of shrinkage variance to be inversely related to the average grease weight of the cores; that is, the heavier the average grease weight the smaller would be the error variance. Table 6, which contains the intra-grade variances of the ewe wool for cores classified according to different grease weights, indicates no significant trend in variance within the particular range observed.

A comparison of the core sampling method with the actual bulk shrinkage is given in table 7.[7] Since the average weight of the cores is about 100 grams,

[6] For detailed discussion of the method see Snedecor (1940), pp. 395–414.

[7] These results are from the same data as found in table 1. However, there are small discrepancies between the core sample means in tables 1 and 7. This is because data in table 7 were corrected by a rescouring factor in order to make more accurate comparisons with the mill yields. In addition, more cores are found in table 7 which includes a few cases where individual cores were composited for each bag. These composite samples were not used in table 1.

TABLE 6. INTRA-GRADE VARIANCE OF EWE WOOL CORES (NOT INCLUDING ¼ BLOOD) OF DIFFERENT GREASE WEIGHTS

Grease wt. of cores (grams)	d/f	σ^2
69 grams or less	11	28.82
70– 79	23	18.35
80– 89	22	25.91
90– 99	31	24.16
100–109	23	24.61
110–119	15	25.60
120–129	13	34.85
130–139	4	30.25
140 grams or more	15	24.60

each sample constitutes only about 0.2 percent of the corresponding bulk grades of wool. The actual differences in shrinkage between the mill yield and core yield, indicated in the column, (*B-A*), are relatively small. The last

TABLE 7. COMPARISON OF MILL YIELDS WITH CORE SAMPLE YIELDS

Wool grade	No. cores	Bulk grease weight (pounds)	Mill yield (*A*) (percent)	Core sample yield (*B*) (percent)	*B–A*	Sampling[a] error (*E*) of *B* for *P*= .05
Aged ewe wool						
Fine French	24	2047	49.2	50.1	+0.9	2.2
Fine staple	57	4650	50.4	51.8	+1.4	1.4
½ Staple	80	6321	52.7	53.5	+0.8	1.2
⅜ Staple	52	3705	57.0	56.7	−0.3	1.5
¼ Staple	11	738	59.0	59.4	+0.4	3.2
Yearling ewe wool						
Fine	15	1218	49.4	50.2	+0.8	1.8
½ Staple	27	2505	49.6	50.2	+0.6	1.3
⅜ Staple	14	1079	54.3	52.6	−1.7	1.8
¼ Staple	3	250	—	59.5	—	3.9

[a] In calculating *E* the following estimates of σ were used: for the ewe wool, 5.48 and for the yearling wool, 3.47. The formula for *E* is, $1.96\,\sigma/\sqrt{N}$.

column contains the sampling error (*E*) of the core yields (*B*) at the .05 level of probability. In all cases the sampling errors are as large as or exceed the observed differences between bulk and sample yields. This indicates satisfactory agreement between observed and expected results, since, on the average, at least 5 percent of the observed differences should be greater than the corresponding sampling errors.

Discussion

It will be observed from formula (1) that when the sampling error, E, is set at 2 percent and t is equal to 2 standard deviations, the required value of N is equal to σ^2. Thus,

$$N = \frac{t^2\sigma^2}{E^2} = \frac{2^2\sigma^2}{2^2} = \sigma^2.$$

Also when E is set at 1 percent and t equals 2,

$$N = 4\sigma^2.$$

Therefore, if the shrinkage variance of the wool clip is known, the mean of N *cores* $= \sigma^2$ would have a sampling error no greater than 2 percent in about 95 percent of the cases. In order to reduce the error to 1 percent, about four times as large a sample would be required as one with an expected sampling error of 2 percent.

The obvious check on the reliability of the core sampling technic is to compare sample means with the bulk shrinkage of entire lots. Data in table 7 indicated satisfactory agreement between the two even though some of the samples were rather small. It would be of interest to know to what extent these differences are due to sampling errors and to what extent they are due to errors in the determination of bulk shrinkage. The variance of the mean difference, σ_d^2, between mill (bulk) and sample shrinkage would be, $\sigma_s^2/N+\sigma_m^2$, where subscripts s and m refer to the sample and the mill shrinkage, respectively. If $2\sigma_d$ represents the sampling error, E', of the mean difference at the .05 level of probability, then,

$$E'^2 = \frac{2^2\sigma_s^2}{N} + 2^2\sigma_m^2,$$

and since the first term is equal to the squared sampling error, E^2, of the sample mean,

$$E' = \sqrt{E^2 + 4\sigma_m^2}.$$

Wollner and Tanner (1941) state that bulk shrinkages may be in error as much as 0.5 percent of the clean yield; if this is assumed to be the fiducial limits when P = .05, the standard error of the bulk shrinkage would be about .25. Substituting this value for σ_m in the equation above:

$$E' = \sqrt{E^2 + .25}.$$

Thus, when values of 2, 1.5, and 1 percent are given for E, the respective values for E' would be 2.06, 1.58, and 1.11.

It is evident that the sampling error of the sample mean agrees closely with the sampling error of the difference when σ_m is no larger than 0.25. It is also clear that as the size of the core sample is increased, σ_m becomes relatively more important in its influence on the sampling error of the mean difference.

A significant increase in the accuracy of the sample was gained by grading the wool. For the ewe wools, the increase in accuracy was 17 percent. However, 5 different grades were contained in this lot. Probably in many bands of western sheep, the range in grades would not be as great as this. It can readily be seen that when the number of grades is less,[8] all else equal, the variance between grades will be smaller and as a result, there will be less advantage in grading wools before sampling them so far as accuracy is concerned.

The results indicated that there was no apparent advantage in sampling each bag within the graded lot of wool so long as each grade was sampled proportionately to its size. For example, if a certain grade of wool were represented by 10 bags from which 30 samples were to be extracted, the results would be the same whether 3 cores were extracted from each of 10 bags or 10 cores were extracted from any 3 bags. However, this would not necessarily hold true when the wool is not graded.

Summary

The core boring method of Wollner and Tanner (1941) was used to sample the clean yield of a wool clip representing about 2700 fleeces which were graded and packed into bags. The data consisted of 264 core samples on which individual clean yields were obtained. The intra-grade variance in clean yield of the aged ewe wool and yearling ewe wool is 30.0 and 12.0, respectively. The difference is statistically significant. The number of cores required to represent lots of wool within specified limits of error was calculated from these estimates of variance. For the ewe wool, the sampling error ($P = .05$) of the mean of 29 cores is equal to 2 percent while 115 cores are required for an error no greater than 1 percent. Only 12 and 46 cores of yearling ewe wool are required for sampling errors no greater than 2 percent and 1 percent, respectively. About 17 percent and 24 percent larger samples of ungraded than graded aged ewe and yearling ewe wool, respectively, would be necessary for the same level of accuracy.

Literature Cited

Burns, Robert H. 1938. Variation in Shrinkage of Wyoming Wools. I. Differences between Duplicate Samples. Wyo. Agr. Exp. Sta. Bul. 225.

Esplin, Alma C., Ralph W. Phillips and Milton A. Madsen. 1941. Wool Scouring Tests in Utah. Utah Agr. Exp. Sta. Bul. 298.

Snedecor, George W. 1940. Statistical Methods. 422 pp. Ed. 3 Collegiate Press, Inc. Ames, Iowa.

Wilson, J. F. The Determination of Yield and Shrinkage of Wool by Scouring Small Samples. 1938. Hilgardia (pub. by Calif. Agr. Exp. Sta.) 2: 149–172.

Wollner, H. J. and Louis Tanner. 1941. Sampling of Imported Wool for the Determination of Clean Yield Content. Ind. and Eng. Chem. (Analytical Ed.) 13: 883–887.

[8] It is assumed that the grades at the extreme ends of the range are those that "became less," since the variance between the 2 grades, *high* and *low*, would be greater than the variance between the 3 grades, high, intermediate, and low.

COMPARISON OF THE YIELDS OF SIDE SAMPLES FROM WEANLING AND YEARLING SHEEP[1]

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Introduction

IN AN experimental sheep breeding program it is generally impractical to retain all lambs to yearling age before evaluating their fleeces and culling the undesirable offspring. Moreover, if the fleece data are used for progeny tests it is important to have this information somewhat in advance of the next breeding season. Weaning age is the logical time to appraise the fleeces, provided the information can be applied satisfactorily in the breeding program.

Schott *et al.* (1942), Pohle, Wolf, and Terrill (1943), and Pohle and Hazel (1944) have shown that the clean wool yield of yearling fleeces can be estimated within practical limits from the percent yield of a side sample. The relationship between the yields of samples and entire fleeces of weanling sheep has not been determined for it is impractical to shear the sheep at this age.

The value of weanling-yearling yield comparisons depends upon there being a high degree of association between the fleece characters at the two ages. If there is a high degree of relationship between samples taken at weanling and yearling ages, then the yield of the weanling sample should be of value in predicting the yield of the yearling fleece.

Most of the weanling-yearling comparisons that have been reported are based on data for one year. Lambert, Hardy, and Schott (1938) and Pohle (1942) studied the relation between weanling and yearling fleece characters of Rambouillet, Corriedale and Columbia sheep at Dubois, Idaho. These workers found significant correlations between the percentages of clean wool in small fleece samples collected at the two ages. Grandstaff (1942) reported large differences between weanling and yearling yields for Navajo sheep in two consecutive years, and low but significant correlations. The latter results indicated that environmental conditions were an important factor in determining the usefulness of weanling data.

This study was made for the purpose of obtaining additional information on various factors that influence yield of clean wool at weanling and yearling ages, and the relationship between the yields of side samples collected at the two ages.

[1] This study was conducted under authority of the Bankhead-Jones Act, by the Bureau of Animal Industry, U. S. Department of Agriculture, in cooperation with the Office of Indian Affairs, U. S. Department of the Interior, at the Southwestern Range and Sheep Breeding Laboratory, Ft. Wingate, N. Mex.

Materials and Methods

A total of 461 crossbred ewe lambs born at the Southwestern Range and Sheep Breeding Laboratory, Ft. Wingate, N. Mex. during the 5-year period 1939–43 were used in this test. More than half of these lambs were either F_1 Corriedale × Navajo or F_1 Romney × Navajo, a few were backcrosses, and the remainder were F_1 (Romney × Navajo) × F_1 (Corriedale × Navajo).

Side samples were collected from the fleeces of the lambs during the first week in September and again during the latter part of May just prior to the time they were sheared. The left side was sampled at weaning age and the right side at yearling age. The samples were taken with an electric clipper from an area approximately 2 × 6 inches in size and placed in individual suction top cans. The approximate weight of wool samples from the weanlings was 8 to 15 grams, and for the yearlings 25 to 35 grams. All samples were scoured with a mild textile soap, and the percentages of clean wool were calculated from bone-dry weights of the samples.

The data were analyzed statistically by the method of analysis of variance, correlation, and regression (Snedecor, 1940).

Experimental Data and Results

Average yields at weaning age, during the five years, ranged from 72.0 percent in 1941–42 to 75.4 percent in 1940–41, a difference of only 3.4 percent as shown in table 1. The yearling yields averaged considerably lower and were much more variable than those of the weanlings; they ranged from 39.6 percent in 1943–44 to 68.3 percent in 1939–40, a difference of 28.7 percent.

TABLE 1. MEAN PERCENT OF YIELD OF CLEAN WOOL BY YEARS, AGES, AND THE RANGE OF MEANS BY PROGENY OF DIFFERENT RAMS, 1939–44

Year	Lambs	Weanling yield		Yearling yield	
		Mean	Range of means from progeny of different rams	Mean	Range of means from progeny of different rams
	number	*percent*	*percent*	*percent*	*percent*
1939–40	47	74.8±1.14	71.0–79.7	68.3±1.99	56.9–75.1
1940–41	86	75.4± .70	73.2–76.7	59.2± .94	57.6–63.7
1941–42	175	72.0± .46	69.4–76.6	52.4± .42	50.3–57.1
1942–43	72	72.5± .59	70.9–75.5	62.6± .78	58.5–65.3
1943–44	81	72.4± .62	70.0–76.6	49.6± .95	44.0–54.5

Comparison of the weanling and yearling yields for the same sheep shows that differences between the two ages varied widely within the 5-year pe-

riod. In 1939–40 average yield of the yearlings was only 6.5 percent less than that of the weanlings, but in 1933–44 the difference between the yields at the two ages was 22.8 percent.

These data clearly show that environmental conditions have a pronounced effect on the percent of clean wool in the fleece, particularly during the period between weanling and yearling ages. The environmental effect is probably greater in the Southwest than it is in most other parts of the country, because of the climatic conditions and sparsity of vegetation. In this region the spring and early summer months are usually dry and windy, and much sand and dirt accumulate in the fleeces. The intensity of these conditions, however, varies considerably from year to year, which has a

TABLE 2. ANALYSIS OF VARIANCE OF THE YIELD OF CLEAN WOOL OF WEANLING AND YEARLING SIDE SAMPLES, 1939–1944

Source of variation	Degrees freedom	Mean squares	
		Weanling samples	Yearling samples
Years	4	214.2*	4171.9*
Rams used same year	33	49.1	135.6*
Lambs (error)	423	36.8	58.9

* Highly significant *F* value.

direct bearing on the percentage yields of clean wool in different years. Environmental conditions prior to weaning age are more favorable. Rainfall is heaviest during the late summer, and there is little or no wind at this season of the year. Moreover, the fleece is quite short during the first few months of growth, which permits much of the dirt to be washed from the wool by rainfall.

The difference in variability of yield at the two ages was also reflected in the means of ram progeny. These ranged from 69.4 to 79.7 percent for the weanlings, and from 44.0 to 75.1 percent for the yearlings (table 1). The range of the yearling means was about three times that of the weanling means. In these data the differences between rams were masked by the influence of environmental conditions.

A summary of the analysis of variance of these data is given in table 2. At weaning age the variance due to differences between the progeny of rams used within years was not significant, but that due to differences between years was highly significant. For the yearlings both the differences between rams and years were highly significant. The relative amount of variance at the two ages is shown by the mean squares. At yearling age the mean square for years was 19 times greater than that at weaning age, and the mean square

for rams was three times the size of the weanling value. In this analysis the error term represented the variance between lambs. It is interesting to note that the mean square of the error term for the yearlings was less than twice that for the weanlings.

An estimate of the percent of total variance which could be attributed to each of the three sources of variation was made.[2] It was found that in both the weanling and yearling data about 5 percent of the variance was due to differences between rams used within years. Differences between years accounted for about 2 percent of the weanling variance, and 41 percent of the yearling variance. Lambs (experimental error) were responsible for about 93 percent of the variance as weanlings, and only 54 percent of the variance as yearlings.

The relation between yields of weanling and yearling samples within years is shown by the following correlation coefficients:

Years	1939–40	1940–41	1941–42	1942–43	1943–44
r	0.24	0.64	0.54	0.40	0.37

The correlation of 0.24 for 1939–40 is non-significant. Those for the other four years are all highly significant, but lower in two instances than those reported by Lambert, Hardy and Schott (1938) and Pohle (1942). These correlations show that the relationship between the yields of weanling and yearling samples differs significantly in some years from that of other years. This may be attributed to the influence of different rams and changing environmental conditions.

The relationship between the weanling and yearling yields of the progeny of individual rams is of special interest, because of its potential application in the selection of rams that will transmit to their offspring the characteristics associated with a high yielding fleece. In this study there were 10 rams that had been used two or more years in the breeding program. Yields of their weanling and yearling progeny were compared on a sire basis. Of the 10 correlations thus obtained, four were non-significant, two were significant, and four highly significant. The explanations for these differences in relationship of weanling and yearling yields of the progeny cannot be given from the data now available. It seems probable that they are associated with other fleece characters transmitted by these rams, such as quantity of yolk, length of staple, and density of fleece. These factors would also have a direct bearing on the relative influence of environmental conditions.

Data for the five years were used to calculate the correlation between the yields of weanling and yearling samples, independent of the effect of

[2] The formula for this analysis was kindly furnished by Dr. L. N. Hazel of the Western Sheep Breeding Laboratory, Dubois, Idaho.

years and rams used within years. A highly significant correlation of 0.45 was obtained. On this basis it appeared that the weanling data might have useful predictive value. The regression of yearling yield on weanling yield was calculated and tested, but proved inaccurate when applied to the data of individual years. For example, the average yield for 1940 was underestimated 11.0 percent, whereas the 1944 yield was overestimated 6.4 percent compared to the actual yields for these years. The regression equation proved even less reliable when used to predict the yearling means of ram progeny. The predicted yields for 1940 were from 0.1 to 19.2 percent lower than the actual yields, and the predicted yields for 1944 were from 3.2 to 11.6 percent higher than the actual yields.

These results emphasize the need for long time studies on yield so that extreme yearly variations will be adequately evaluated. They also demonstrate that at the present time weanling data on yield cannot be used satisfactorily in a breeding program conducted under Southwestern range conditions.

Summary

Data on the clean wool yields of side samples collected at weanling and yearling ages from 461 crossbred ewe lambs raised at the Southwestern Range and Sheep Breeding Laboratory, Ft. Wingate, N. Mex. during a 5-year period were analyzed.

Average yields at yearling age were from 6.5 to 22.8 percent lower and much more variable than the weanling yields for the same sheep.

Approximately 5 percent of the total variance in yield at both weanling and yearling ages was due to the effect of rams used within years. Differences between years were responsible for about 2 percent of the weanling variance, and 41 percent of the yearling variance. Thus, differences between lambs represented about 93 percent of the total variance in the weanling yields and only 54 percent at yearling age.

The relation between the weanling and yearling yields for individual years and progeny groups varied greatly, ranging from non-significant to highly significant correlations. The correlation between the yields of weanling and yearling samples, independent of the effect of years and rams used within years, was 0.45, a highly significant value. The regression equation calculated from these data, however, was found to have little practical value for estimating yearling yields from weanling data because of the extreme variations resulting from environmental conditions.

Further long-time studies are needed to determine the relationship between yield, other fleece characters, and environmental factors.

Literature Cited

Grandstaff, J. O. 1942. Evaluation of Fleece Yield in the Improvement of Navajo Sheep. (Abstract) JOURNAL OF ANIMAL SCIENCE, 1: 58.

Lambert, W. V., J. I. Hardy and R. G. Schott. 1938. A Preliminary Study of the Relation Between the Fleece Characteristics of Weanling and Yearling Sheep. Amer. Soc. An. Prod., Proc., pp. 298–303.

Pohle, E. M. Relationship Between Weanling and Yearling Fleece Characters in Range Sheep. JOURNAL OF ANIMAL SCIENCE, 1: 229–235.

Pohle, E. M. and L. N. Hazel. 1944. Clean-Wool Yields in Small Samples from Eight Body Regions as Related to Whole-Fleece Yields in Four Breeds of Sheep. JOURNAL OF ANIMAL SCIENCE, 3: 159–165.

Pohle, E. M., H. W. Wolf and C. E. Terrill. 1943. Clean Wool-Yield Variations Among Regions of Rambouillet Fleeces. JOURNAL OF ANIMAL SCIENCE, 2: 181–187.

Schott, R. G., E. M. Pohle, D. A. Spencer and G. W. Brier. 1942. Wool Yields in the Small Side-Sample as Related to Individual Whole-Fleece Yields in Four Breed-Groups of Sheep. JOURNAL OF ANIMAL SCIENCE, 1: 137–144.

Snedecor, G. W. 1940. Statistical Methods. Ed. 3. Iowa State College Press, Ames, Iowa.

PREVENTION AND CURE OF MUSCULAR STIFFNESS ("STIFF-LAMB" DISEASE) IN LAMBS

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THE "stiff-lamb" disease or muscular stiffness is an ailment of young suckling lambs. Under field conditions the extent of the disease varies from year to year. It is most common in April or May while the ewes and lambs are in dry lot. It has been reported in many of the states where sheep are raised, and in several foreign countries.

It has been shown by Willman and associates (1930, 1931, 1934, 1940) that methods of management of the ewes such as the amount of exercise and the level of feeding, have little or no effect on the occurrence of the disease. In these investigations it was shown that the addition of vitamin C to the ration is not effective as a preventive. Experiments conducted during the last 15 years have thoroughly demonstrated that the feeding to the ewes of a ration of alfalfa and cull beans, or a ration of alfalfa, cull beans, oats and barley is followed by a high incidence of the disease in the lambs. It does not develop in lambs whose dams are fed mixed clover and timothy hay, corn silage and oats and wheat bran. The addition of wheat bran or wheat germ meal to the "stiff-lamb-producing" rations has been very effective in preventing the disease (table 1).

Post-mortem examinations show striking muscular lesions in many lambs. These appear to the naked eye as whitish areas in the muscle substance. Their extent varies, but they have been found at one time or another in nearly all of the skeletal muscles. A small proportion of the lambs shows heart lesions, which appear as white patches located under the endocardium, commonly in the right ventricle. Intra-muscular hemorrhages or edematous conditions have been found in some lambs. Extensive microscopic lesions have been found in the muscles of stiff lambs with no gross lesions. Normal lambs in the experimental groups have been free from the characteristic lesions. A more complete description of symptoms, pathological anatomy and histopathological changes was reported by Willman, Asdell and Olafson (1934).

It was recognized that the stiff-lamb disease has some points of similarity to the muscle dystrophy found by Madsen and co-workers (1935) in guinea

[1] Acknowledgment is made to W. A. Hagan, Dean of the New York State Veterinary College and his associates, who have conducted the post-mortem examinations of lambs used in these trials and R. D. Crook, V. H. Melass and E. W. Klosterman, graduate assistants in Animal Husbandry, who helped with certain trials. Acknowledgment is also made to Professor L. A. Maynard and C. M. McCay of the Department of Animal Husbandry for their advice and assistance.

TABLE 1. SUMMARY OF TREATMENTS AND NUMBER OF EWES USED IN STUDY OF "STIFF-LAMB" DISEASE, AND THE RESULTS OBTAINED

Lambing season	Treatment	No. ewes	No. lambs being raised	No. of stiff lambs
1930 to 1939	Ewes fed mixed clover and timothy hay, corn silage and concentrate mixture of two parts oats and one one part wheat bran, by weight	167	205	0
1930 to 1942	Ewes fed alfalfa hay and a concentrate mixture of three parts each of oats and barley and four parts cull beans, by weight	235	298	79
1934, 1935 and 1937	Ewes fed alfalfa hay and a concentrate mixture of five parts each of oats and barley, 50 *parts wheat bran* and 40 parts cull beans, by weight	50	68	4
1940, 1941 and 1942	Ewes fed alfalfa hay and a concentrate mixture of five parts each of oats and barley, 50 *parts wheat germ meal* and 40 parts cull beans, by weight. Lambs creep fed oats, barley and *wheat germ meal*	56	76	1
1943 and 1944	Ewes fed alfalfa hay and cull beans	52	65	49
1943	Ewes fed alfalfa hay, cull beans and *wheat germ meal* and lambs creep fed oats and *wheat germ meal*	29	34	0
1944	Ewes fed cull beans and alfalfa hay and both ewes and lambs fed *mixed tocopherols*	20	20	0
1944	Ewes fed cull beans and alfalfa hay and lambs fed *alpha-tocopherol*	24	21	0

pigs, rabbits, lambs and goats fed cod-liver oil. Morgulis and others (1936, 1938) reported that certain substances in the wheat germ and in some other feeds are essential for the maintenance of normal muscle tissue. Cary (1939) found that when rabbits are fed a cow ration consisting of a grain mixture, poor quality hay and small amounts of cod-liver oil, they eventually become paralyzed due to muscular dystrophy. He reported that synthetic alpha-tocopherol is effective in curing this paralysis. These findings and the excellent results obtained at the Cornell Station from feeding wheat bran and wheat germ meal (1940) indicate that the muscular dystrophy found in lambs may be due to a deficiency of vitamin E. The feeding of wheat germ meal has prevented the occurrence of the stiff-lamb disease in the flocks used in these experiments (see table 1) and also in a number of flocks of cooperating New York flock owners.

The Possible Role of Vitamin E

In order to test the value of wheat germ oil as a cure for the stiff-lamb disease, wheat germ oil was given as a drench to 7 stiff lambs in the spring of 1940. One of the lambs died and 6 lambs recovered. The following year wheat germ oil was given as a drench to 4 stiff lambs and wheat germ oil and glycine to 3 others. No treatment was given to a group of 4 stiff lambs. One lamb died and 2 recovered in the group treated with wheat germ oil and glycine. All recovered in the group given wheat germ oil and also in the group that was given no treatment. The results from these tests failed to show that these supplements as given had any curative value.

In 1942 mixed tocopherols[2] were fed to the ewes for 10 weeks before lambing and to the ewes and lambs from lambing time in the spring until the flock was turned to pasture. For some unknown reason there were no stiff lambs in this lot or in the check lot fed a ration that had produced stiff lambs for 12 consecutive years.

An experiment (see table 1) was conducted in 1943–44 with 3 lots of 24 ewes each and their lambs to determine whether the disease would be prevented by feeding supplements of vitamin E with a ration that produced the disease. All the ewes in this experiment were fed a ration of cull beans (chiefly red kidney) and first and second-cutting alfalfa hay. Lot I received no other feed. The ewes in lot II also received for three months, beginning February 22, 1944 (24 days before the first lamb was born) 2 doses weekly of a 8.25 percent solution of mixed tocopherols in cottonseed oil at the rate of 9 ml. per dose. This vitamin supplement was fed on the beans. Two ml. of this solution were given as a drench at birth and once a week thereafter to each lamb in this lot (lot II). The ewes in lot III were given only beans and alfalfa, but their lambs were given as a drench 2 ml. of an olive oil solution containing 140 mg. of d, l-alpha-tocopherol acetate. This is 6 or 7 times the requirement of rabbits as reported by Eppstein and Morgulis (1941). On May 22 there were 20 lambs in lot II and 21 lambs in lot III. No stiff lambs were produced in these lots while 13 lambs became stiff out of 27 raised by the ewes in lot I which had been fed no vitamin E supplements.

Alternate lambs of those in lot I with definite symptoms of the disease were treated with a water-soluble disodium salt of d, l-alpha-tocopherol phosphoric acid ester. One hundred mg. of this material dissolved in about 5 ml. of sterile water were injected subcutaneously. Four lambs were given only one dose each and 3 were given a second dose after an interval of 3 to 8 days. Six of the 7 lambs treated made rapid recovery, the symptoms dis-

[2] The mixed tocopherols were supplied by Distillation Products, Incorporated, Rochester, New York, and the alpha-tocopherol compounds by Hoffman-LaRoche, Incorporated, Nutley, New Jersey.

appearing in 7 to 19 days following the first treatment. One stiff lamb showed marked symptoms when he was 26 days old. He died 8 days later although treatment had been given when he was 26 and 29 days old. The autopsy revealed pneumonia, and gross lesions of muscular dystrophy in the skeletal muscles. Five lambs died in the group of six untreated stiff lambs and the characteristic lesions were found. The lamb in this group that recovered never showed marked symptoms.

The vitamin E content of the rations fed in these experiments has not been determined. Hathaway and Davis (1934) have reported that twenty to twenty-five percent of alfalfa furnished enough vitamin E to allow rats to cast litters. The ewes included in the experiments reported here have produced lambs that seemed normal at birth and made satisfactory gains before they exhibited symptoms of muscular stiffness. It is possible, however, that there is not enough vitamin E in the diet of the suckling lambs to prevent the occurrence of the disease. Vitamin E may not be the only factor involved in this disease. Further studies are in progress.

Summary

The results of the experiments reported here indicate that the lack of vitamin E in the ration of the lambs may be the cause of the stiff-lamb disease. In the trials conducted in 1933–44 the disease was prevented by feeding an oil solution of mixed tocopherols to the ewes and to the lambs or by feeding an oil solution of d, l-alpha-tocopherol acetate to the lambs after birth. Six of 7 stiff lambs recovered following the subcutaneous injection of a water solution of the disodium salt of d, l-alpha-tocopherol phosphoric acid ester, while 5 of 6 untreated stiff lambs died.

Earlier work showed that the number of stiff lambs was reduced markedly when liberal quantities of wheat bran were substituted for part of the oats and barley in a ration which also included cull beans and alfalfa hay. The inclusion of liberal amounts of wheat germ meal in the rations fed to the ewes and its use in the creep feed almost entirely prevented the disease from occurring.

Literature Cited

Anonymous. 1930. The Relation of Feeding and Management to "Stiff-lamb" Trouble. Cornell University Agricultural Experiment Station, Forty-Third Annual Report, Part II, pp. 32–33.

Cary, C. A. 1939. The Relation of Vitamin E to Nutritional Paralysis: Rpt. of the Chief of the Bureau of Dairy Industry, U. S. Dept. of Agric., Bureau of Dairy Industry, Div. Nutrition and Physiology, p. 24.

Eppstein, S. H. and S. Morgulis. 1941. The Minimum Requirement of Rabbits for d, l-alpha-tocopherol. Jour. Nut. 22: 415–424.

Hathaway, I. L. and H. P. Davis. 1934. The Vitamin E Content of Certain Dairy Feeds. Neb. Agr. Exp. Sta. Res. Bull. 73, pp. 1–7.

Madsen, L. L., C. M. McCay and L. A. Maynard in cooperation with George K. Davis and J. C. Woodward. 1935. Synthetic Diets for Herbivora, With Speical Reference to the Toxicity of Cod-liver Oil. Cornell Memoir 178, pp. 1–53.

Morgulis, Sergius and Howard C. Spencer. 1936. A Study of the Factors Concerned in Nutritional Muscular Dystrophy. Jour. Nutrition 11: 573–591.

Morgulis, Sergius, Violet M. Wilder and S. H. Eppstein, 1938. Further Studies on Dietary Factors Associated with Nutritional Muscle Dystrophy. Jour. Nutrition 16: 219–227.

Willman, John P., S. A. Asdell, W. T. Grams and W. A. Hagan, 1931. The Stiff-lamb Disease. Amer. Soc. of An. Prod. Proc., pp. 231–234.

Willman, J. P., S. A. Asdell and Peter Olafson. 1934. An Investigation of the Cause of the Stiff-lamb Disease. Cornell Bull. 603, pp. 1–20.

Willman, J. P., C. M. McCay, F. B. Morrison and L. A. Maynard. 1940. An Investigation of the Cause of the Stiff-lamb Disease. Amer. Soc. of An. Prod. Proc., pp. 185–192.

PHENOTHIAZINE AS AN ANTHELMINTIC FOR BREEDING EWES[1]

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THE anthelmintic properties of phenothiazine for internal parasites of sheep have been investigated by numerous research workers since its introduction by Harwood, Habermann, and Jerstad (1939) and Habermann and Harwood (1940). Phenothiazine was compared to the combination nicotine sulphate—copper sulphate drench by Shorb, Habermann and Heemstra (1941) and to the combination drench, nicotine sulphate drench and tetrachlorethylene capsules by Thorp and Keith (1943). The results of these studies indicate that phenothiazine was the most effective treatment for roundworms of sheep. Britton, *et al.* (1942) claimed beneficial results in the control of parasitism in lambs by the 1–15 phenothiazine salt mixture using large numbers of lambs on which fecal counts were made. The efficiency of the phenothiazine salt mixture and drench was studied extensively at this Station last year (Thorp, Henning and Shigley, 1944). Various mixtures of phenothiazine in salt were administered. The 1–9 mixture of phenothiazine and salt produced the most consistent results under our conditions. Therefore, the following general recommendations were made: Treat all the sheep in the flock during the late fall or early winter with the phenothiazine drench. Repeat this treatment in the spring one or two weeks after all the ewes have lambed. Then, place the entire flock on the 1–9 phenothiazine and salt mixture. Drench the lambs in the flock with phenothiazine when they are 3 to 4 months of age. If it is a wet, warm season and the lambs show any evidence of parasitism, it may be necessary in some cases to drench them again.

Peterson, Kammlade and Webb (1944) concluded that the 1–14 mixture of phenothiazine and salt protected sheep from an excessive parasite infestation when the animals were relatively free at the beginning and kept from parasitized sheep; however, it did not protect sheep when placed on a recently contaminated pasture.

Any drug or chemotherapeutic agent used as an anthelmintic is considered somewhat toxic to the animal which is being treated. In the introduction of any new treatment such as phenothiazine it is natural for some sheepmen to

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regard this treatment as responsible for any abortions, weak lambs, or breeding difficulties in their flocks. Therefore it was thought advisable to maintain a group of breeding ewes on the 1–9 phenothiazine and salt mixture continuously for a period of at least five years. The purpose of a long continuous treatment would be to study the effect, if any, on metabolism, blood counts, reproduction or breeding efficiency of both the ewes and those lambs reserved for replacements in the flock from year to year. This has been carried with the same group of ewes and a portion of their lambs for the past three years.

Materials and Methods

The sheep used in this study were as follows: Twenty Merino ewes; ten of their first year's experimental lambs; and ten of the second year's lambs and ten lambs of the common mutton breeds. In addition to these, four ewe flocks in widely separated areas in the State were included in the last season's investigations. Two of these farm flocks were in the northern portion of the State, one in the central part, and one in the southwestern portion. This was to determine if there were any differences in the type of parasite infestation due to different climatic conditions or management practices.

Fecal examinations were made each week during the summer months with the exception of the farm flocks from which samples were taken three times during the season for the northern and central flocks and four times for the flock in the southern portion of the State. The fecal samples from the farm flocks were refrigerated until counts were made in the laboratory. All parasite egg counts were made according to the method described by Shorb, *et al.* (1941), which had proved very satisfactory during the previous two years' work. White blood cell counts, red cell counts, and differential counts, along with hemoglobin determinations, were made periodically during the experiment. The Haden-Hauser hemoglobinometer was used for the hemoglobin determinations.

Experimental Data and Discussion

The sheep used in this work were divided into three main groups. First, the twenty Merino ewes which have been on the 1–9 phenothiazine and salt mixture for the past three years; second, the lambs produced by these same Merino ewes and kept as replacements; and third, the farm flocks of ewes of varied breeding throughout the State maintained under practical farm conditions. The parasite infestation of the Merino ewe flock as indicated by weekly parasite egg counts during the grazing season is shown for each of the last three years in figure 1 (1, 2, 3). This group of ewes has not received any treatment except the 1–9 salt mixture continuously summer and winter

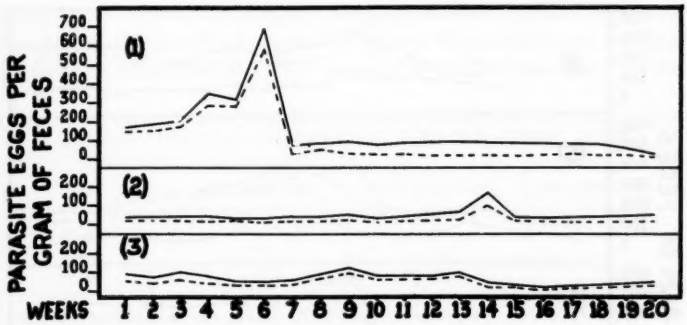

Figure 1. The Average Weekly Egg Counts On:
(1) 20 Merino ewes given 1–9 phenothiazine and salt at beginning of experiment.
(2) Same 20 ewes as (1) but second grazing season.
(3) Same 20 ewes as (2) but third grazing season.
——— Total Count.
------ Haemonchus contortus Count.

since they were drenched at the beginning of this study. Chart No. 1 represents the average weekly parasite egg count for the first season. The counts shown for the first six weeks represent the period during which no treatment was given after which the ewes were drenched once and placed on the 1–9 phenothiazine and salt mixture. Charts No. 2 and 3 represent the average weekly counts for the last two years. It is important to note that there is no appreciable difference in the counts for the three seasons after the program was started. The effect of this treatment upon the infestation of the lambs from the Merino ewes is shown in figure 2 (4 and 5). Chart No. 4 represents the average weekly parasite egg count for the ten lambs which were kept and permitted to graze with the ewes during the second season. Chart No. 5 represents the counts for the ten lambs which were kept with the Merino ewes this last season. All of these lambs had access to the 1–9 salt mixture at all times since birth. Charts No. 6 and 7 (figure 2) show the weekly parasite egg counts for lambs kept with their ewes but which had received no treatment. The ewes in this case had been treated fall and spring but received no other treatment. Chart No. 6 represents the egg counts for lambs under these conditions for the 1943 grazing season and Chart No. 7 for those lambs under these conditions during the 1944 season.

The lambing record for the twenty Merino ewes on the long-time administration of the 1–9 salt mixture is shown in table 1. The average counts for the farm flocks of ewes which were started on this program last fall and this spring is shown in table 2.

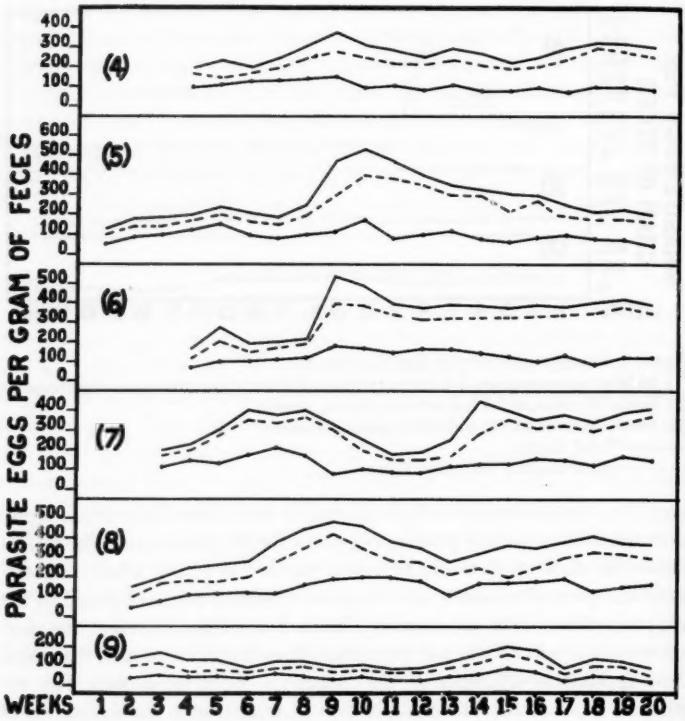

Figure 2. The Average Weekly Egg Counts On:

(4) 10 Merino lambs given 1–9 phenothiazine and salt with ewes during the second grazing season.

(5) 10 Merino lambs given 1–9 phenothiazine and salt with ewes during the third grazing season.

(6) 10 lambs not treated but with ewes treated fall and spring only, second grazing season.

(7) 10 lambs not treated but with ewes treated fall and spring only, third grazing season.

(8) 10 lambs given 1–9 phenothiazine and salt second season but not with ewes.

(9) Same 10 lambs as (8) but the following year as yearlings.

——— Total Count.

- - - - - - Haemonchus Count.

●–●–● Average of Other Species.

In figures 1 and 2, space does not permit the showing of the average weekly parasite egg count for all species of nematodes other than the Haemonchus. Counts were made, however, on the Strongyloides, Tricho-

strongylus, Cooperia, Ostertagia, Oesophagostomum, Nematodirus, and Bunostomum species of nematodes. In figure 2, these species are averaged and then plotted on the charts. The presence of parasite eggs other than the

TABLE 1. RECORD OF REPRODUCTION ON MERINO EWES ON CONTINUOUS 1–9 PHENOTHIAZINE AND SALT MIXTURE FOR THREE YEARS

Year	No. ewes bred	No. lambs born	No. pairs of twins
1942	10*	11	1
1943	15	17	2
1944	15	17	2

* Four yearling and one adult ewes were not bred the first year. The other 10 ewes reproduced in all three years.

TABLE 2. THE AVERAGE NUMBER OF PARASITE EGGS PER GRAM OF FECES FOR FARM FLOCKS CONSISTING OF TWENTY SHEEP EACH

Flock name and date of sample	Parasite								Total
	Strongyloides	Trichostrongylus	Cooperia	Ostertagia	Haemonchus	Oesophagostomum	Nematodirus	Bunastomum	
Andrews									
4/11/44*	18	14	8	9	73	4	22	5	484
6/9/44	17	19	4	6	84	4	13	3	499
8/8/44	7	4	3	4	45	2	3	6	224
10/2/44	8	6	2	3	31	2	4	3	153
Kosa									
5/11/44*	60	50	22	45	172	7	16	6	1294
7/24/44	7	5	5	9	42	2	3	3	148
9/15/44	5	5	3	10	41	4	3	2	142
Lovelace									
5/11/44*	43	41	14	46	230	5	6	7	943
7/24/44	7	3	3	17	35		2	2	141
9/15/44	7	2	5	22	28	3	2	3	154
Dale									
4/25/44*	24	13	8	11	152	4	9	5	531
6/23/44	8	5	6	4	24		1		144
10/24/44	11	3	5	2	29	3	2	4	140

* These samples were taken just before the phenothiazine program was inaugurated in the spring.

above species was not observed consistently or were present in insignificant numbers. Tapeworm eggs were observed from time to time in the various groups, particularly the lambs; however, no attempt was made to count these eggs.

Phenothiazine is considered by many to be one of the best anthelmintics for sheep, and is one of the least toxic anthelmintics. As indicated above, a flock of twenty Merino ewes has been maintained on a 1–9 phenothiazine and salt mixture for the past three years. The parasitic infestation as indicated by the weekly parasite egg count has not changed materially during the past two years. The blood studies have not differed from those reported last year (Thorp, Henning and Shigley, 1944). Three of the older ewes in this flock died during this last season. Upon autopsy they showed some enlargement of the spleen and possible degeneration of the liver. In two of the ewes some post mortem changes had taken place; however, none of these ewes had shown any evidence of toxicity on the basis of blood studies. A histopathological study of the tissues showed some fatty degeneration of the liver, congestion of the sinuses of the spleen but no changes in the kidney. It will be necessary to continue studies on tissues from the remainder of the ewes before definite conclusions can be drawn as to whether these changes are due to the phenothiazine.

A study based on the average weekly parasite egg counts for the Merino ewe flock during the past three grazing seasons indicates that there is very little yearly difference in the parasitic infestation. There were two ewes that had a considerably higher than average Haemonchus count. One of these ewes was in the group on the first year's experiment and one in this last summer's trial. Although the average egg count for this group of ewes is very low, several individuals in the flock may have a relatively high count and act as carriers for the lambs. Studies reported by Dinaburg (1944) indicate that very few if any of the economically important parasites such as the Haemonchus species live over the winter on the pastures in this section of the country. It is therefore very important that all the sheep in the flock be as free from parasites in the spring as possible. This will help prevent the highly susceptible lamb from becoming infested. From the standpoint of the breeding ewe herself, the 1–9 phenothiazine and salt mixture is a reasonably efficient anthelmintic under average conditions.

A study of table 1 indicates that the continuous administration of the 1–9 phenothiazine and salt mixture does not effect the lambing percentage. The number of lambs produced by these ewes during the past three years is normal for this section. They all appeared normally healthy and as vigorous as under average conditions. From these limited numbers we have observed no detrimental effects from phenothiazine on reproduction in the Merino ewe.

A careful study of charts No. 4 and 5 (figure 2) indicates very definitely for two consecutive seasons that lambs with ewes on the continuous 1–9 mixture of phenothiazine and salt will have a relatively high infestation of parasites. Chart No. 4 represents the counts for lambs during the first graz-

ing season and No. 5 for the second. During these two seasons climatic conditions were not favorable for the development of a heavy parasite infestation. Although the average counts for the ewes were very low there were still enough parasites to infest the lambs. The young lamb will not consume much of the 1–9 salt mixture, which is another factor contributing to the development of a moderate infestation in these lambs.

The average weekly parasite egg counts shown in charts No. 6 and 7 (figure 2) represent two groups of lambs which were allowed to run with ewes that had been treated spring and fall but received no other treatment. It will be noted that both of these groups of lambs ended the trial period with a relatively heavy parasite infestation, considering that both of the seasons were comparatively dry.

The average weekly parasite egg counts for a group of lambs maintained on the 1–9 phenothiazine and salt mixture, along with their dams, since birth is shown in chart No. 8 (figure 2). A rather heavy infestation developed during the trial period. The average weekly egg count for these lambs as yearlings the following season is shown in chart No. 9 (figure 2). This decided drop in the average weekly count was undoubtedly brought about by the administration of the 1–9 mixture; however, there was some residual infestation which these yearlings could carry over to lambs the following year.

The farm flocks represented by the average counts shown in table 2 were not under as close observation or supervision as the experimental flocks; however, the trend in the counts appears similar to that observed in those flocks which were under a rigidly controlled experiment.

A careful study of this last season's weekly parasite egg counts for the ewes comparing them to the previous two seasons' data indicates that the continuous administration of the 1–9 salt mixture will, under the conditions of the experiment, leave enough residual infestation to produce a mild parasitism in the lambs. It is therefore important that the fall and spring drench be kept in the program for eliminating the important nematode parasites. The toxicity from the continuous use of the 1–9 mixture has not been determined conclusively; therefore its use during the winter months is not recommended in the northern areas.

Summary

The phenothiazine drench and 1–9 salt mixture is recommended as an anthelmintic for breeding ewes.

The 1–9 phenothiazine and salt mixture, prepared by mixing 1 pound of phenothiazine powder with 9 pounds of granular salt, is considered a preventive measure.

The toxicity of the continuous administration of the 1–9 mixture has not been definitely established over a long period of time; however, in this form it is considered a relatively non-toxic anthelmintic. No indication of toxicity has been observed when administered in this form to sheep during the grazing season only.

A low residual parasite infestation in the ewe will produce a significant infestation in the lamb.

The 1–9 phenothiazine salt mixture is a satisfactory procedure when supplemented with the fall and spring drench as previously recommended.

Literature Cited

Britton, J. W., R. L. Miller and H. S. Cameron. 1942. The Control of Parasitism in Sheep with Phenothiazine in a Salt Lick. Cor. Vet., 32: 4, 400–406.

Dinaburg, A. G. 1944. The Survival of the Infective Larvae of the Common Ruminant Stomach Worm, Haemochus Contortus, on Outdoor Grass Plots. Am. Jour. Vet. Res., 5: 14, 32–37.

Habermann, Robert T. and Paul D. Harwood. 1940. Efficacy of Recrystallized Phenothiazine for the Removal of Nematodes from the Gastrointestinal Tract of Sheep. Vet. Med., 35: 1, 24–29.

Harwood, Paul D., Robert T. Habermann and Arthur C. Jerstad. 1939. Efficacy of Commercial Phenothaizine in the Removal of Roundworms from Sheep. Vet. Med., 34: 7, 440–443.

Peterson, E. H., W. G. Kammlade and R. J. Webb. 1944. The Effectiveness of a 1–14 Phenothiazine-Salt Mixture in Controlling Neamtode Infection in Sheep. Am. Jour. Vet. Res., 5: 16, 228–233.

Shorb, D. A., R. T. Habermann and L. C. Heemstra. 1941. Comparison of the Efficacy of Phenothiazine and Copper Sulphate-Nicotine Sulphate Mixture as Anthelmintics for Sheep. Vet. Med., 36: 11, 502–506.

Thorp, W. T. S., W. L. Henning and J. F. Shigley. 1944. The Efficiency of the Phenothiazine Salt Mixture and Drench for Sheep. JOURNAL OF ANIMAL SCIENCE, 3: 3, 242–249.

Thorp, W. T. S. and T. B. Keith. 1943. The Use of Phenothiazine for Sheep and Suggested Method of Administration. Vet. Med., 38: 215–220.

THE RAPIDITY OF THE STORAGE OF THIAMINE AND ITS RETENTION IN PORK MUSCLE[1]

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In a previous report (Miller, *et al.*, 1943) it was shown that the thiamine content of pork muscle may be greatly increased by feeding a diet naturally rich in this vitamin or by feeding a ration supplemented with pure crystalline thiamine. These experiments involved feeding periods of from 99 to 140 days. Furthermore, it was shown that pork shoulder is consistently lower in thiamine content than pork loin. Preliminary observations were also reported for two pigs which were given 50 mg. of thiamine hydrochloride daily for 22 days. The pork-thiamine values for these pigs were of the same order as those for the pigs which had been on a high thamine regime for 99–140 days. These results indicated that the saturation point for thamine had been reached in the muscle tissues of the latter pigs. The data also indicated that the saturation of pork muscle by thiamine might occur quite rapidly. The experiments reported here were planned to give further information on these points.

Experimental Procedure

Thirty-six pigs of the Chester White, Duroc Jersey and Berkshire breeds, weighing approximately forty pounds each, were used in this experiment. These pigs were fed a basal ration composed of yellow corn, wheat, 60 percent digester tankage, ground alfalfa hay, limestone and salt, and which contained 1.2 mg. of thiamine per pound. The respective proportions of the ingredients of this ration were changed periodically, thereby reducing the protein content of the ration from 19.7 percent to 14.7 percent as the pigs grew. These changes did not affect the thiamine content of the ration. The pigs were kept in dry lots or indoors on cement floors, and did not have access to green feed. The experimental treatments were as follows: (1) Six pigs were fed the basal ration without supplementary thiamine for a period of 133 days. (2) Six pigs were fed the basal ration plus a daily supplement of 50 mg. of pure crystalline thiamine for a period of 155 days. (3) Six pigs were fed the basal ration for a period of 160 days. For 35 days, beginning 70 days previous to slaughter, they were given a daily supplement of 50 mg. of pure crystalline thiamine. Thus they did not receive thiamine during the 35 days immediately preceding slaughter. (4) Six pigs were fed the basal ration and

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a daily supplement of 50 mg. of pure crystalline thiamine for 35 days immediately preceding slaughter. Three other groups of three pigs each were given 50 mg. of supplementary thiamine daily for periods of 8, 15 and 22 days, respectively, immediately preceding slaughter. Two pigs received the supplementary thiamine for 29 days.

At the time of slaughter the pigs weighed approximately 190–210 pounds. Samples of the pork were analyzed in accordance with procedures described by Miller, *et al.* (1943).

Results and Discussion

The results are given in table 1. The pork-thiamine values for pigs fed the basal ration consisting of natural feedstuffs of average thiamine content correspond very closely with our previous results. They confirm previous observations to the effect that pork loin is richer in thiamine than pork shoulder, and that pork muscle is much higher in thiamine content than pork liver. The feed of these pigs contained 1.2 mg. of thiamine per pound and the average daily intake of thiamine was 5.3 mg.

The total average daily thiamine intake of the pigs which received a daily supplement of 50 mg. of pure crystalline thiamine for the entire feeding period of 155 days was approximately 11 times that of the pigs referred to above. The pork thiamine values for these pigs correspond closely with those previously published (Miller, *et al.*, 1943) for pigs on a high thiamine feeding regime, and are approximately twice as high as those for the pigs which received the usual amount of thiamine found in average feeds. These results emphasize the fact that the nutritional status of the pig is one of the factors determining the thiamine content of pork.

The pork-thiamine values for pigs which received 50 mg. of supplementary thiamine daily for 8, 15, 22 and 35 days, respectively, immediately preceding slaughter show that at this level of thiamine intake, the vitamin accumulates very rapidly in the muscle tissues. The thiamine content of the muscle tissues is approximately doubled in 35 days of high thiamine intake. The data for individuals show some variation between pigs on the same treatment, but this variation does not obscure the fact that the pig can store thiamine rapidly in muscle tissue. The pork-thiamine values for the pigs which received thiamine for 8 days show that there is a definite and rapid response to thiamine administration. It also appears that the muscle tissue becomes saturated with thiamine quite rapidly. The pork-thiamine values for the 35-day pigs and for the pigs given thiamine for 155 days correspond well with our previously-published values for pigs on a high thiamine regime.

The pork-thiamine values for pigs which received 50 mg. of thiamine daily for 35 days and then received no extra thiamine for the 35 days immediately

preceding slaughter are relatively high and indicate that extra thiamine which is stored in pork-muscle tissue is retained by the tissue for some time after thiamine is withdrawn from the diet. Since these pigs gained in body weight quite rapidly during the last 35 days preceding slaughter, it

TABLE 1. THE AVERAGE THIAMINE CONTENT OF PORK FROM PIGS WHICH RECEIVED A BASAL RATION WITHOUT SUPPLEMENTARY THIAMINE, AND WITH 50 MG. DAILY OF THIAMINE FOR VARIOUS PERIODS. (THIAMINE EXPRESSED AS MICROGRAMS PER GRAM OF FRESH TISSUE AND PER GRAM OF DRY MATTER)

No. of pigs	Shoulder		Middle of loin		Ham end of loin		Liver	
	Fresh basis	Dry matter basis	Fresh basis	Dry matter basis	Fresh basis	Dry matter basis	Fresh basis	Dry matter basis
Basal ration, no supplementary thiamine								
6	7.6±0.5	27.2±2.0	9.8±0.5	34.7±2.0	10.0±0.5	35.8±1.7	3.6±0.2	11.5±0.6
50 mg. thiamine daily for 8 days preceding slaughter								
3	10.2±0.5	36.7±1.6	11.6±0.4	42.6±0.6	12.6±0.2	47.0±2.0	3.2±0.2	10.3±0.4
50 mg. thiamine daily for 15 days preceding slaughter								
3	11.7±1.0	43.6±3.1	15.2±1.3	55.8±4.4	15.9±0.7	58.3±1.8	5.2±0.7	16.7±2.3
50 mg. thiamine daily for 22 days preceding slaughter								
3	13.8±1.5	44.7±3.8	17.4±0.6	56.5±3.4	17.1±0.5	58.0±5.2	5.5±0.4	17.4±1.0
50 mg. thiamine daily for 35 days preceding slaughter								
4	18.4±0.9	69.4±3.1	24.8±1.4	93.4±4.2	23.8±1.1	90.0±3.6	6.8±0.6	21.0±1.3
50 mg thiamine daily for 155 days preceding slaughter								
4	14.1±1.0	53.2±4.1	22.8±1.0	87.0±5.1	20.8±0.8	77.5±2.4	4.1±0.3	14.5±1.3
50 mg. thiamine daily for 35 days, then no supplementary thiamine for 35 days preceding slaughter								
6	14.8±0.6	56.0±2.6	19.6±0.8	73.1±3.5	20.4±1.1	77.0±5.0	4.8±0.4	15.2±1.1

may be doubtful if the pork-thiamine values actually represent any real loss of thiamine from the muscle tissue. This statement is made with full recognition of the fact that the tissues representing the body gains of pigs at this stage of their development, are comprised of a high percentage of fat.

It is impossible to determine accurately the retention of thiamine in a growing animal by tissue analyses. The alternative is to keep the animal on a

maintenance plane of nutrition for the desired length of time. However, the present results indicate strongly that the pig is probably different from other animal species which become depleted of thiamine stores quite rapidly.

This suggests that thiamine may be stored in pork muscle in a manner quite different from that in other species. Furthermore, thiamine may occur

TABLE 2. THE THIAMINE CONTENT OF THE PORK FROM PIGS WHOSE STORAGE OF THIAMINE WAS ATYPICAL (THIAMINE EXPRESSED AS MICROGRAMS PER GRAM OF FRESH TISSUE AND PER GRAM OF DRY MATTER)

Pig no.	Shoulder		Middle of loin		Ham end of loin		Liver	
	Fresh	Dry matter	Fresh	Dry matter	Fresh	Dry matter	Fresh	Dry matter
50 mg. thiamine daily for 155 days								
8	10.9	43.4	15.2	60.3	14.3	55.6	2.9	10.1
9	7.5	26.8	11.9	44.8	12.7	48.1	3.7	12.9
Ave.	9.2	35.1	13.6	52.6	13.5	51.9	3.3	11.5
50 mg. thiamine daily for 35 days previous to slaughter								
24	10.2	40.1	14.2	55.9	15.0	59.4	5.7	17.8
25	13.3	52.6	15.4	59.3	17.5	67.4	6.4	20.1
Ave.	11.8	46.4	14.8	57.6	16.3	63.4	6.1	19.0
50 mg. thiamine daily for 29 days previous to slaughter								
22	8.4	33.1	13.4	53.3	13.4	53.1	5.4	17.6
23	10.5	40.3	16.6	64.1	16.2	63.0	4.8	15.6
Ave.	9.5	36.7	15.0	58.7	14.8	58.1	5.1	16.

in pork muscle tissues in possibly several forms, and the forms in which it occurs in high and low concentrations may be different. Unpublished data, obtained by the authors, dealing with the stability of thiamine in pork, favor this hypothesis.

In some instances we have encountered pigs which exhibit a low storage response to thiamine feeding. Data for six such pigs are given in table 2. Having determined pork thiamine values for large numbers of pigs whose thiamine intakes were definitely known, the authors are of the opinion that, within the limits of normal variation, pigs give a uniform response to dietary thiamine, as shown by the thiamine content of the pork. The pigs, for which

data are given in table 2, are considered to be atypical with respect to thiamine storage in that they stored thiamine inefficiently or possessed low saturation capacities for this vitamin. Pigs numbers 9 and 22 stored little if any of the vitamin; low degrees of storage are shown by the other pigs. Experiments are planned to seek an explanation for these apparently anomalous cases.

Summary

Data are presented which show that thiamine can be stored at a rapid rate in pork muscle, and that these tissues can become saturated within 35 days or less. It is suggested that the nutritional status and the physiological status of the pig are factors which determine the thiamine content of pork. The pig differs from other animal species studied, with regard to the relatively slow rate of loss of stored thiamine after extra dietary thiamine has been withdrawn. Occasionally pigs are encountered which, for reasons still unexplained, are limited in their ability to store thiamine rapidly and efficiently.

Literature Cited

Miller, R. C., J. W. Pence, R. A. Dutcher, P. T. Ziegler and M. A. McCarty. 1943. The Influence of the Thiamine Intake of the Pig on the Thiamine Content of Pork with Observations on the Riboflavin Content of Pork. J. Nutrition, vol. 26, p. 261.

BREEDING SYSTEMS USED TO PRODUCE THE HIGHEST YIELDING GUERNSEY AND HOLSTEIN COWS

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MUCH has been written on the subject of breeding systems and the question is still one very much to the fore. Some writers advocate the improvement of milking strains of cattle by linebreeding or by inbreeding, while others believe that the best results can be obtained by outcrossing selected inbred lines, in the manner of the hybrid corn breeder. To most, close inbreeding is anathema, and especially to the commercial farmer. The questions asked in this paper are pertinent. How have the highest yielders actually been produced? Has one method of breeding proved more successful than another in practice? Some unpublished work by the writer has shown clearly that human intellectual ability is markedly decreased by inbreeding. Do other types of productiveness show the same tendency?

In order to answer these questions, names and details of records of the 100 highest fat yielding Guernsey cows and the 100 highest milk yielding Holstein cows have been taken from records published in herd books. Six-generation pedigrees were constructed for each and the coefficients of inbreeding were calculated using Wright's (1922) formula. No allowance was made for the inbreeding of ancestors, but in view of the small amount of inbreeding generally found and its remoteness this is not a serious omission. In addition, the coefficients of inbreeding for the sires and dams were calculated in the five generations recorded on the work sheets. As a basis for comparison a coefficient of inbreeding less than 3.13 percent (equivalent to half first cousin matings) was regarded as not inbred, from 3.13 percent to 6.25 percent (first cousin matings or the equivalent) as slightly inbred, and above 6.25 percent as inbred. The individual pedigrees were examined for evidence that some particular breeding system had been followed in the production of the superior animal under scrutiny. Lastly, available yields of dams and of grand dams were entered to find whether a certain level of production was needed in the immediate ancestors of the superior cows.

Data and Discussion

Guernseys

The hundred highest fat yielding Guernsey cows had annual yields ranging from 1213.1 pounds to 911.1 pounds. These cows were sired by 94 bulls, 6 of whom had two daughters each in the group. They were the produce of 99 cows. Five dams with daughters in the group were themselves amongst

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the hundred. There is, therefore, some tendency for descendents to remain in the group but little for the animals which produced one of them to produce more than the one.

As some of the pedigrees traced back into imported stock (Guernsey or Alderney foundation stock) it was found possible to obtain 97 usable pedigrees only, so that the following data refer only to these cows. The average coefficient of inbreeding was 1.97 ± 0.22 percent. The standard deviation was 3.34 and the range from 0 to 14.70 percent. The pedigrees and the breeding processes which they represent may be classified as follows:

Not inbred (below 3.13 percent)	78 cows
Sire and dam not inbred	47 cows
Outcross of a slightly inbred parent	14 cows
Outcross of a strongly inbred parent	17 cows
Slightly inbred (between 3.13 percent and 6.25 percent)	10 cows
Inbreeding or line breeding	6 cows
Partial outcross of an inbred sire	3 cows
Partial outcross of a very inbred sire (24.22 percent)	1 cow
Inbred (above 6.25 percent)	9 cows
Inbreeding or line breeding	7 cows
Partial outcross of an inbred sire	2 cows

Only two of these cows were the product of half brother and sister matings. In three cases the inbreeding was to more than one family and in two it was to one family.

While no figures are available of the degree of inbreeding of the Guernsey breed as a whole it seems evident that this group of cows is not more inbred than the breed as a whole. It would not be easy to find any cows of the last few generations which are not inbred to either the May Rose or Masher blood to some extent.

It is evident from these figures that there is no breeding system which has proved more useful than another when its success is gauged by the number of cows so bred within the first hundred. They are, for the most part, inbred to an insignificant extent. None are really highly inbred.

The maximum fat yields of 60 of the dams of these cows were known. The range was from 1063.4 pounds to 302.0 pounds, with an average of 632.4 pounds. For the 43 known mothers of the dams the range was 854.0 pounds to 307.1 pounds, with an average of 559.3 pounds. The mothers of the sires, 76 known, ranged from 934.7 pounds to 260.0 pounds with an average of 636.8 pounds. The significance of these figures will be discussed later in the paper after a consideration of the Holstein Friesian results.

Holsteins

The hundred highest milk yielding Holstein cows had annual yields ranging from 38,607 pounds to 30,193 pounds. These cows were sired by 76

bulls. One had 9 daughters, two had 4, two had 3, and six had 2 daughters in this group. One cow, herself in the group, had two daughters and another cow in the group had one daughter in the first hundred. Each one of these cows, both dams and daughters, were by "repeater" sires. There is somewhat more tendency than there was amongst the Guernseys for the influence of a few animals to secure entrance into the group for their offspring, but this is largely due to the number of animals from one herd who were in the first hundred.

It was possible to complete the pedigrees of all the cows. The average coefficient of inbreeding was 1.79 ± 0.19 percent. The standard deviation was 2.79 and the range from 0 to 13.04 percent. All these figures differ but little from those for the Guernsey cows. The pedigrees and the breeding processes which they represent may be classified as follows:

Not inbred (below 3.13 percent)	78 cows
Sire and dam not inbred	53 cows
Outcross of a slightly inbred parent	11 cows
Outcross of a strongly inbred parent	14 cows
Slightly inbred (between 3.13 and 6.25 percent)	12 cows
Inbreeding or line breeding	11 cows
Partial outcross of an inbred sire	1 cow
Inbred (above 6.25 percent)	10 cows
Inbreeding or line breeding	5 cows
Partial outcross of an inbred sire or dam	5 cows

Amongst the inbred cows both in this breed and in the Guernsey the system described as an outcross is that of reducing the degree of inbreeding.

Lush, Holbert and Willham (1936) found that in 1931 the average coefficient of inbreeding for the Holstein breed was 4.0 ± 0.5 percent. This was obtained by tracing random lines back to the earliest registered cattle so it is higher than the coefficient obtained from 6 generation pedigrees used in this study. However, the conclusion is justified that the average coefficient of inbreeding of the hundred highest yielding Holsteins is no higher, and possibly less than the average for the breed.

The results of this study indicate that no system of breeding has been more successful than another in producing the superior milkers, except that there is evidence that in certain good inbred lines with a level of inbreeding around 20 percent, the best cattle have been produced when the degree of inbreeding has been reduced to a level around 10 percent. However, this may not be the reason for the success of these cows; it may have been that the matings which produced them brought together the genes necessary for high milk production.

The maximum milk yields of 68 of the dams of these hundred cows were known: They ranged from 31,764 pounds to 12,284 pounds with a mean of

23,000 pounds. The 84 known mothers of the sires ranged from 37,381 pounds to 12,133 pounds with an average of 24,600 pounds. The 69 known mothers of the dams ranged from 34,510 pounds to 14,814 pounds with an average of 23,000 pounds. It is worth noting that 52 of the dams, 70 of the sires' dams and 57 of the dams' dams gave over 20,000 pounds of milk in their best year. Evidently, unless the dam and granddams all give over 20,000 pounds of milk in a year, there is not much chance that a cow will produce over 30,000 pounds herself.

Discussion

The evidence given in this paper strongly suggests that the system of breeding is of little significance in the production of cattle with the highest milk or fat yield. It may be deduced that strong inbreeding is detrimental, preventing the expression of genes for high yield, since there are no really highly inbred cows in the group, and since the best results were obtained in one Holstein herd when the coefficient was reduced. On the other hand the evidence does show, as might have been expected, that the yields of the parents and grandparents are of paramount importance in determining whether a cow will be a breed leader. In the Guernsey breed a cow has little chance of becoming a leader unless her sire and dam are both worth at least 600 pounds or more of fat. In the Holstein she stands little chance unless her parents are worth at least 20,000 pounds of milk.

A recent paper by Steele (1944) compares superior and poor-performing thoroughbred horses on the basis of five generation pedigrees. He found that the degree of inbreeding was very small, 1.4 per cent. Brockelbank and Winters (1931) estimated the coefficient of inbreeding in 100 Shorthorn show winners and found it to be 1.9 percent. On the other hand Willham (1937) found that Hereford prize winners are more inbred than the average for the breed. However, evidence is now available that, for intellectual capacity, milk and fat yield, and race track ability, the possession of superior parents is far more important than the method of breeding followed. None of the popular breeding systems has produced more than its share of superior animals though there is some evidence from one herd of dairy cattle that a reduction of the degree of inbreeding is necessary before the highest yields can be attained. Yet the outcrosses made to do this were outcrosses with good bulls which produced superior progeny when they were mated to unrelated good cows so that the results may have been owing to concentration of good genes and not to the outcross.

Recent work with swine is pertinent. Winters, *et al.* (1944) have found that the degree of increased vigor obtained when inbred lines are crossed is in close keeping with the decrease in the coefficient of inbreeding of the

crossbreds and that superior lines appear to produce the superior crossbreds. Also, Comstock and Winters (1944) emphasize the necessity for maximum attention to selection in the development of inbred lines. This work with swine greatly strengthens the argument put forward in the discussion in this paper.

Summary

The breeding of the hundred highest fat-yielding Guernsey cows and the hundred highest milk yielding Holstein cows were analyzed to obtain their coefficients of inbreeding and to find whether they had been produced to a greater degree by any one method of breeding.

The average coefficient of inbreeding found in each case was close to that of the breed as a whole. No system of breeding was especially noteworthy in the production of these superior animals, but there is a suggestion that reduction of strong inbreeding is an advantage. It was found that superiority of the parents was more important than the system of breeding followed.

Literature Cited

Brockelbank, E. E. and L. M. Winters. 1931. A Study of the Methods of Breeding the Best Shorthorns. J. Hered., 22: 245–249.

Comstock, R. E. and L. M. Winters. 1944. A Comparison of the Effects of Inbreeding and Selection on Performance in Swine. JOURNAL OF ANIMAL SCIENCE, 3: 380–389.

Lush, J. L., J. C. Holbert and O. S. Willham. 1936. Genetic History of the Holstein Freisian Cattle in the United States. J. Hered. 27: 61–72.

Steele, D. G. 1944. A Genetic Analysis of Recent Thoroughbreds, Standardbreds, and American Saddle Horses. Ky. Agr. Exp. Sta. Bul. 462, 1–27.

Willham, O. S. 1937. A Genetic History of Hereford Cattle in the United States. J. Hered., 28: 283–294.

Winters, L. M., P. S. Jordan, R. E. Hodgson, O. M. Kiser and W. W. Green. 1944. Preliminary Report on Crossing of Inbred Lines of Swine. JOURNAL OF ANIMAL SCIENCE, 3: 371–379.

Wright, S. 1922. Coefficients of Inbreeding and Relationship. Am. Nat., 56: 330–338.

THE EFFECT OF FINISH AND RIPENING PERIOD OF BEEF ON THE KEEPING QUALITY OF THE MEAT QUICK FROZEN AND STORED FOR FIFTEEN MONTHS[1]

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RECENT developments in the quick freezing of meat and in the freezer locker industry have increased the possibilities of storing meat and equalizing the amount available to consumers at all seasons of the year. These developments focus attention on the quality of meat after long periods of storage. Previous work (Shrewsbury, *et al.*, 1942) has shown that pork stored frozen for about one year retains a considerable amount of its original quality. The present study covers similar experiments with beef. The object was to determine the effect of the finish of steers and effect of different ripening periods of the beef carcass on the keeping quality of the meat after it had been quick frozen and stored at a temperature of about 0°F. for 17 months.

Experimental Procedure

The data are from two identical experiments in which eight calves, averaging 494 pounds each were full fed a ration of corn, silage and hay. At the end of three months 2 steers (underfinished) were removed from the feed lot and slaughtered for the meat studies; two steers were removed and slaughtered at the end of six months (medium finished), two at nine months (finished) and two at twelve months (overfinished). The underfinished steers averaged 583 pounds and were graded common; the medium finished steers averaged 795 pounds and graded medium to good; the finished steers averaged 941 pounds and graded medium to choice; the overfinished steers averaged 1197 pounds and graded choice to prime. One half of each carcass was ripened 14 days and the other half 21 days. Hamburger was made from the carcass immediately after chilling. The steaks were cut from the short loin, wrapped individually in moisture proof cellophane (Dupont 300 M.A.T.) and placed in a cloth stocking. They were then frozen in a Birdseye multiplate freezer at −26°F. The frozen cuts going into storage were packed in corrugated paper boxes, sealed and placed in the storage room which was held at a temperature of about 0°F. The hamburger was packed in pound boxes which were wrapped in cellophane and sealed prior to freezing.

Chemical Studies

The results of the chemical analysis are presented in table 1. In general, there were no marked differences in changes in chemical constituents be-

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TABLE 1. CHANGES IN CHEMICAL CHARACTERISTICS OF BEEF STEAKS AND HAMBURGER QUICK FROZEN AND STORED FOR 15 MONTHS[1]

Finish of steers	Av. increase in ammonia, N, mg./100 g.		Av. change in moisture, in percent		Av. change in pH		Av. change in refractive index		Av. increase in perioxides, milliquivelants		Av. change in free acids, Mg/G		Av. change in saponification No.	
	A[2]	B[3]	A	B	A	B	A	B	A	B	A	B	A	B
Beef steaks														
Underfinished	9.6	9.9	+3.0	+5.0	+0.1	+0.1	+.0003	+.0001	1.8	4.2	+4.2	+1.9	−1	0
Medium finished	13.7	14.1	+3.0	+6.0	±0.0	−0.2	+.0004	−.0002	1.6	5.1	+1.5	+1.2	−5	+5
Finished	11.0	20.4	+2.0	+1.0	+0.1	−0.1	−.0003	−.0002	0.2	2.8	+0.3	+0.2	0	+1
Overfinished	20.1	18.6	±0.0	−1.0	−0.1	+0.3	+.0004	+.0002	1.7	2.2	+0.9	+0.8	+2	+2
Hamburger														
Underfinished	15.0	—	+2.0	—	+0.3	—	.000	—	1.2	—	+1.1	—	c	—
Medium finished	13.0	—	+5.0	—	+0.1	—	+.0001	—	1.9	—	−1.0	—	+3	—
Finished	3.5	—	+3.0	—	−0.2	—	−.0001	—	1.3	—	−1.8	—	0	—
Overfinished	12.2	—	+3.0	—	−0.1	—	+.0004	—	2.3	—	−3.2	—	+2	—

[1] Nitrogen, moisture and pH determinations made on lean portion, other analyses on rendered fat portion.
[2] A = Carcass ripened at 38–40° F. for 14 days before freezing.
[3] B = Carcass ripened at 38–40° F. for 21 days before freezing.

tween the beef ripened for 14 days and 21 days. Somewhat less ammonia nitrogen accumulated in meat from underfinished steers than from better finished ones but differences in other chemical constituents were not correlated with the finish of the steers. Ammonia nitrogen, free fatty acid and peroxide development was considerable in the meat after storage for 15 months indicating deterioration. Moisture, pH, refractive index and saponification number changes were minor and not considered to be indicative of deterioration of the meat.

The changes in the hamburger were very similar to those in the steaks. In both cases the changes in chemical constituents were not of sufficient magnitude to indicate spoilage.

Palatability Studies

In the cooking and palatability studies, rib cuts, steaks, ground meat and pot roasts were used. A total of 784 samples were cooked. One sample of each was left unfrozen and the remainder quick frozen. The frozen cuts were thawed in an electric refrigerator at about 40°F. for 24 hours before cooking. The ribs were roasted in a 300°F. oven to an internal temperature of 158°. The steaks were broiled to an internal temperature of 122°F., turned and cooked to an internal temperature of 158°F. The pot roasts were seared, then braised in covered pans in a 300°F. oven for 2¼ hours. The ground meat cakes (210 grams) were baked in a 300°F. oven for 40 minutes.

The cooked samples were weighed and while still hot, were judged by the palatability committee. The portion of each cut to be used for the tensile strength determinations was stored overnight in a refrigerator. A Warner-Bratzler shear machine was used for determining the tensile strength. The samples for the shear tests were taken from the longissimus dorsi muscle. The total cooking losses and the losses as drippings were determined.

A summary of the averages of the palatability scores, the tensile strength measurements, and the percentage of cooking losses of the unfrozen steaks and the frozen steaks held in storage for 15 months are given in table 2. These results represent in a general way the findings for the other cuts used in the study.

There was a tendency for the 21-day ripened samples to be scored somewhat lower in desirability of flavor of fat and lean and in composite grade than the 14-day ripened samples, regardless of the degree of finish of the steers. In most cases, the difference between the scores for the desirability of flavor of the unfrozen and the 15-month-stored frozen samples was greater for the fat than for the lean.

The steaks from the well-finished steers were judged somewhat more juicy than those from the under- or medium-finished animals. Neither the

TABLE 2. PLATABILITY SCORES,[1] TENSILE STRENGTH, AND COOKING LOSSES OF FRESH STEAKS AND FROZEN STEAKS STORED 15 MONTHS

Finish of steer	Sample	Desirability			Intensity			Juice		Tenderness	Tensile[2] strength, pounds	Percent cooking Losses		Composite score[3]
		Odor	Flavor of lean	Flavor of fat	Odor	Flavor of lean	Flavor of fat	Character	Quantity			Drippings	Total	
Carcass ripened 14 days														
Underfinished	Fresh	5.4	5.5	4.9	4.8	4.5	4.5	4.5	4.6	5.6	16.0	8.1	25.6	5.0
	Stored frozen	5.3	5.3	4.8	4.7	4.7	5.0	4.5	4.6	6.2	13.7	9.1	29.4	5.0
Medium finished	Fresh	6.0	5.8	5.6	5.0	5.2	4.9	5.1	5.1	4.8	17.9	9.3	27.7	5.0
	Stored frozen	5.6	5.6	4.8	4.6	4.9	4.8	4.5	4.7	4.9	21.1	11.5	32.0	4.9
Finished	Fresh	6.0	6.1	5.9	5.3	5.3	5.2	5.3	5.5	5.4	16.6	12.3	29.7	5.6
	Stored frozen	5.7	5.5	4.8	5.0	4.8	5.1	5.0	5.1	4.9	19.4	12.6	32.7	5.3
Overfinished	Fresh	6.1	6.0	5.6	5.4	5.3	5.3	5.7	5.4	4.7	18.4	15.8	31.7	5.2
	Stored frozen	5.6	5.7	4.7	4.4	5.0	5.0	5.1	5.3	4.6	19.8	17.6	33.7	5.0
Carcass ripened 21 days														
Underfinished	Fresh	5.4	5.4	4.6	4.9	4.7	4.8	4.3	4.4	5.4	13.9	9.3	28.0	4.8
	Stored frozen	4.7	4.5	3.7	4.8	4.9	5.2	4.3	4.6	5.1	14.9	7.4	25.9	4.0
Medium finished	Fresh	5.5	5.4	5.1	5.0	5.2	5.0	4.8	5.0	5.3	15.7	11.0	28.6	4.8
	Stored frozen	5.3	5.2	4.3	4.5	4.8	4.9	4.9	5.0	4.8	16.4	9.1	27.6	4.4
Finished	Fresh	5.6	5.6	5.5	5.0	5.2	5.0	4.9	5.1	4.9	17.5	13.1	29.0	5.0
	Stored frozen	5.3	5.1	4.1	4.9	4.8	5.0	4.8	4.9	5.1	19.7	16.5	33.7	4.6
Overfinished	Fresh	6.0	6.0	5.4	5.3	5.4	5.0	5.3	5.5	5.1	20.1	18.8	34.1	5.5
	Stored frozen	5.5	5.5	4.1	4.7	5.1	5.0	4.8	5.1	4.7	19.8	18.0	38.4	4.7

[1] Determined by a committee of judges.
[2] Determined by Warner-Bratzler shear machine.
[3] Score values: 7—excellent; 6—very good; 5—good; 4—medium; 3—fair; 2—poor; 1—very poor.

judges' scores nor the tensile strength measurements showed any decided trend in the degree of tenderness of the steaks attributable either to the period of ripening, or the period of frozen storage. The steaks from the under-finished animals were somewhat more tender, according to the shear tests, than those from the better-finished groups.

There was a trend for the percentage of cooking losses, particularly the drippings, to increase with the degree of finish of the animals, but no marked difference attributable to period of ripening, or to freezing and storage, was apparent.

Data on the ribs, in general, showed the same trends as noted in the data on the steaks.

The pot roasts received low scores for quantity and richness of juice, and the scores for the desirability of flavor of the fat were considerably lower than those given the ribs and steaks. However, neither degree of finish, period of ripening, nor period of frozen storage noticeably affected these scores.

The palatability scores given the samples of ground meat (hamburger) were not appreciably affected by the treatment of freezing and storage, nor by the degree of finish of the steers.

None of the samples were inedible; only two of the more than 780 samples were given an average composite grade lower than 3 points, which, on the score card, corresponded to fair quality. After 15 months of frozen storage, the samples were still considered palatable.

Histological Studies

The method of preparation of muscular tissues for microscopic study has considerable influence upon their histological appearance (Johnson, Andrews and Shrewsbury, 1943) and it is essential that all procedures be carefully regulated. Each meat specimen was sampled in triplicate by the following procedure: A block of loin muscle approximately 24 mm. in length, 8 mm. wide and 8 mm. thick was removed with a sharp razor blade or scalpel. This block was in turn cut into 3 portions not more than 8 mm. square. One block was fixed in 10 percent Formalin, another in Carnoy's Chloroform-Alcohol-Acetic Acid, and a third in Formalin-Alcohol-Acetic Acid. The tissues were then processed by the methods outlined in detail by Johnson *et al.* (1943).

Normal skeletal muscle, e.g., beef loin, is made up of groups of parallel muscle fibers held together by connective tissue. Each fiber is covered by a thin, structureless membrane, the sarcolemma and between and surrounding the individual fibers is a thin fibrous covering, the endomysium. Small groups of muscle fibers are held together by interstitial connective tissue, the perimysium, and these bundles in turn form the muscle proper and are surrounded by connective tissue, the epimysium. The structure of fresh, un-

[2] Determined by Warner-Bratzler shear machine.
[3] Score values: 7—excellent; 6—very good; 5—good; 4—medium; 3—fair; 2—poor; 1—very poor.

frozen loin muscle is shown in figure 1 (top). The individual fibers are closely packed together, show little evidence of shrinkage due to method of preparation, and are representative of the normal structure as described by most

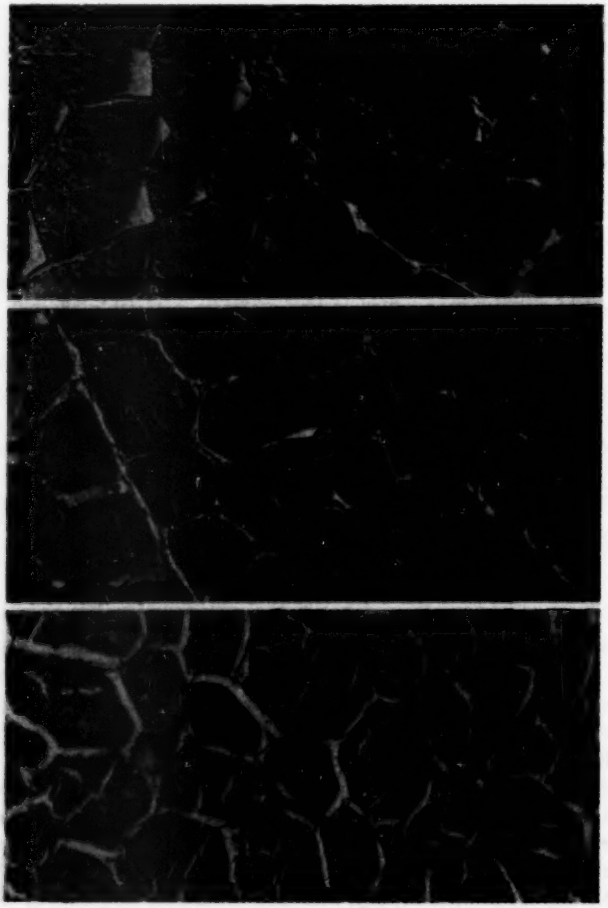

Figure 1. Top: Normal beef muscle fixed in Alcohol-Acetic Acid within 1–2 hours after slaughter. Note the close arrangement of the muscle fibers. Middle: Beef muscle ripened 14 days, frozen and stored for 15 months. There is slight shrinkage and separation of the fibers. Bottom: Beef muscle ripened 21 days, frozen and stored for 15 months. There is some shrinkage and separation of the fibers and some cracking within the fibers. All photos are 220×.

histologists. Photomicrographs of loin muscle frozen and stored for 15 months are shown in figure 1 (middle and bottom). The muscle in figure 1 (middle) was from a medium finished steer, ripened for 14 days, frozen for 15 months and fixed in Formalin-Alcohol-Acetic-Acid fixative. The individual muscle fibers show evidences of slight shrinkage and separation, but these characteristics frequently appear in unfrozen meat and are almost always present in formalin fixed tissues. Figure 1 (bottom) was from a finished steer ripened 21 days, frozen for 15 months, and fixed in Carnoy's Chloroform-Alcohol-Acetic Acid. There is slight separation of the muscle fibers and some cracking or separation within the individual fibers. However, these changes are often seen in fresh muscle and are often not observed in large areas of frozen muscle.

As pointed out by Johnson *et al* (1943), it is rather difficult to draw definite conclusions as to the effects of freezing upon the histological structure of muscle. The shrinkage and separation of muscle fibers and bundles and general distortion of the tissues have been reported by other workers as evidences of freezing damage. In this laboratory the same characteristics have been found in some unfrozen samples. In certain instances triplicate muscle specimens processed by different "so called" standard methods have been entirely dissimilar in microscopic appearance. The evidence at hand under our conditions indicates that individual muscle fibers and bundles can be subjected to freezing temperatures for as long as 15 months without undergoing appreciable histological change.

Summary

1. Changes in chemical constituents of beef stored frozen for 15 months were not of sufficient magnitude to indicate spoilage.

2. Palatability tests of beef stored in a frozen condition for 15 months showed slight, but definite deterioration in quality of the product.

3. Studies of frozen stored beef indicate that the muscle fibers and bundles can be subjected to freezing temperatures for as long as 15 months without undergoing appreciable histological change.

4. No relationship was found between the finish of the steers, length of the ripening period of the carcass, and the chemical, palatability and histological changes that resulted from storage in the frozen state.

Literature Cited

Shrewsbury, C. L., L. W. Horne, W. Q. Braun, R. Jordan, O. Milligan, C. M. Vestal and N. E. Weitkamp. 1942. Chemical Histological and Palatability Changes in Pork During Freezing and Storage in the Frozen State. Purdue University Agricultural Experiment Station Bulletin No. 472, 1–35.

Johnson, E., F. N. Andrews and C. L. Shrewsbury. The Preparation of Muscular Tissue for Histological Study. 1943. JOURNAL OF ANIMAL SCIENCE, 2: 244–250.

DISTILLERY SLOPS FOR FATTENING STEERS[1]

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DISTILLERY slop or "stillage" is the residue from the fermentation of grains and other materials such as molasses, potatoes, and other products after alcohol has been removed through distillation. The residue contains a very high percentage of water (92–95 percent). Approximately 35 gallons of slop result from the mashing of one bushel of grain. Distillation of grain mash removes most of the carbohydrates leaving essentially all of the protein, fat and fiber of the grain in the slop. When only alcohol is removed from the mash, the stillage is usually spoken of as "whole slop" or "thick slop." When the coarser solids are screened from the stillage after leaving the still for the manufacture of distillers' dried grains, the remaining slop is known as "thin slop." When the thin slop is evaporated to a consistency of about 35 percent solids and then dried on drums until there remains a product containing only about 7 percent moisture, the residue is known as distillers' dried solubles. This product is a comparatively new one, having been produced commercially only since 1940. It appears to be especially valuable for use in poultry mashes and as a source of vitamins and minerals.

Distillery slops have been used for many years for cattle feeding at or comparatively close to the distilleries. Until recent times much of the total slop has been turned loose in streams and wasted. Since industrial alcohol has become so important for war purposes, the distilleries have been running their plants to full capacity, thus making available millions of barrels of stillage. Although considerable expansion has occurred in the drying of slop products, it has been a problem to find ways of making a profitable disposal of these great quantities of slops, especially at the smaller distilleries. Some distilleries have furnished it gratis to farmers and feeders, resulting in the feeding of thousands of cattle within a radius of 25 miles of a plant. Most plants are now charging from 5 to 10 cents per barrel. In most of the cattle feeding operations slop made from corn mash has been used more extensively than other types. Comparatively few experimental data are available on slop feeding, but it has been quite generally known that farmers and feeders have gotten good results with corn slop. During the last two years, however, other grains and grain products have had to be used. These have included wheat, both whole and in the form of granular wheat flour, sorghum grains,

[1] The investigation reported in this paper was made by the Kentucky Agricultural Experiment Station, the Meadow Lawn Distilling Co., Inc., and the Bureau of Animal Industry, Agricultural Research Administration, U. S Department of Agriculture, cooperating.

TABLE 1. PERCENT SOLIDS, CRUDE PROTEIN, FAT, N.F.E., AND ASH AND CALORIES OF GROSS ENERGY PER GRAM OF DRY MATERIAL AND MICROGRAMS OF CAROTENE PER 100 GRAMS IN SLOPS AND HAY USED IN STEER FEEDING TEST FROM JULY 13, 1943, TO FEBRUARY 21, 1944 (224 DAYS)

Type of feed and and contents analyzed	Date of sampling							Average
	7-31-43	9-7-43	10-6-43	11-2-43	11-30-43	12-28-43	1-26-44	
Granular wheat								
Solids (percent)	5.9	5.7	5.8	5.9	5.6	9.6	6.0	6.36
Crude protein (percent)	2.4	2.4	2.4	2.5	2.4	3.7	2.0	2.54
Fat (percent)	0.1	0.4	0.1	0.1	0.2	0.3	0.1	0.19
N.F.E. (percent)	2.9	2.3	2.8	2.6	2.4	4.9	3.4	3.04
Ash (percent)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Gross energy (calories)[1]	4925	4909	4847	4843	4831	4899	4845	4871
Carotene (micrograms)[2]	3.3	5.6	4.4	5.0	6.2	4.5	6.2	5.03
Whole wheat								
Solids (percent)	6.0	5.0	9.7	9.6	6.2	9.7	10.2	8.06
Crude protein (percent)	2.5	1.7	2.8	2.9	2.2	3.1	3.0	2.60
Fat (percent)	0.3	0.3	0.4	0.4	0.2	0.4	0.4	0.34
N.F.E. (percent)	2.3	2.2	4.7	4.8	2.8	4.7	5.0	3.79
Ash (percent)	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.39
Gross energy (calories)[1]	4729	4743	4884	4836	4869	4889	4865	4831
Carotene (micrograms)[2]	1.0	5.2	4.9	7.8	7.9	10.3	12.7	7.11
Corn and wheat								
Solids (percent)	5.2	8.2	7.6	10.8	6.2	7.3	5.1	7.2
Crude protein (percent)	1.6	1.9	2.3	3.4	2.3	2.4	2.1	2.29
Fat (percent)	0.4	0.4	0.5	0.8	0.5	0.4	0.4	0.43
N.F.E. (percent)	2.5	4.8	3.7	4.9	2.5	3.7	2.0	3.44
Ash (percent)	0.3	0.2	0.4	0.5	0.4	0.4	0.2	0.34
Gross energy (calories)[1]	4786	4755	4673	4770	4706	4777	4817	4755
Carotene (micrograms)[2]	4.0	13.7	26.4	36.6	25.3	34.6	20.0	22.94
Hay								
Solids (percent)	93.4	93.4	93.8	93.0	94.6	90.0	93.6	93.1
Crude protein (percent)	8.9	8.8	6.6	7.8	8.1	11.0	11.0	8.9
Fat (percent)	2.2	2.7	2.0	1.9	2.0	2.5	2.9	2.3
N.F.E. (percent)	38.8	37.9	43.3	39.5	40.5	35.9	36.5	38.9
Ash (percent)	6.0	5.8	5.2	6.2	5.7	6.0	6.9	6.0
Gross energy (calories)[1]	4172	4090	4173	4097	4155	4018	4155	4123

[1] Expressed as calories per gram.

[2] Expressed as micrograms per 100 grams of slop.

and rye which have been incorporated into the mash, either singly or in combination. When the slops from these new mashes were fed, with little or no other feed except low quality roughage, to fattening cattle, some nutritional deficiencies, particularly that of vitamin A, would usually appear after cattle had been on feed for from 4 to 6 months.

In view of the gradually increased quantities of slops from wheat mashes becoming available, and indications of vitamin A deficiencies occurring in cattle fed the wheat slop, a research problem of some importance presented itself. Accordingly this work was undertaken to obtain some information on the value of wheat slops for fattening cattle.

This paper reports an experiment conducted at the Meadow Lawn Distillery near Louisville, Kentucky. As the work covers only one year, this should be considered as a progress report.

Material and Methods

In this study 3 groups of cattle, supplied by the distillery, were fed slop made from mashes of granular wheat, whole wheat, and corn and wheat (50 per cent each). Each of the three types of stillage would be considered as "whole slop." The corn and wheat slop fed after January 4 was thin slop. All three varied considerably throughout the progress of the test in percentage of solids, especially during the last two months. The granular wheat (hull and germ removed) was the most uniform in this respect, showing the least variation. The granular wheat slop averaged about 6.36 percent solids as compared to 7.2 percent for the corn and wheat slop and 8.06 percent for the whole wheat. The whole wheat slop was a more uniform product throughout the test in its protein and fat contents than the other types of slop used. It was from a low-yielding distillery and was exceptionally high in quality. The corn and wheat slop was the most variable of all the slops in percent of solids, protein, fat, nitrogen-free extract, and ash. The corn and wheat slop used in the last two periods of the test was thin slop, running only slightly above 5 percent solids. Further details on the composition of the slops are shown in table 1.

The cattle used were long yearling well bred Hereford steers weighing from about 700 to 725 pounds as feeders at the beginning of the test. They were fed all of the slop they would take with approximately 5 pounds of lespedeza-grass hay per head daily. Salt was kept before them at all times and limestone flour for a period of 84 days. During the remainder of the experimental period the limestone was added directly to the slops at the rate of 1 ounce per each 10 gallons, both to reduce the acidity and to insure an adequate intake of calcium.

Data and Discussion

All groups of steers made relatively good daily gains for the first 168 days (see figure 1) averaging up to that time 1.69 pounds per head for group 1 steers fed granular wheat slop, 2.00 pounds for those in group 2 fed whole wheat slop, and 1.93 pounds for the group 3 steers fed the corn and wheat

slop. The rate of gain for the last 56 days decreased somewhat, particularly in the case of group 3, which made practically no gain. The other two groups, however, made fairly satisfactory daily gains of around 1.5 pounds during

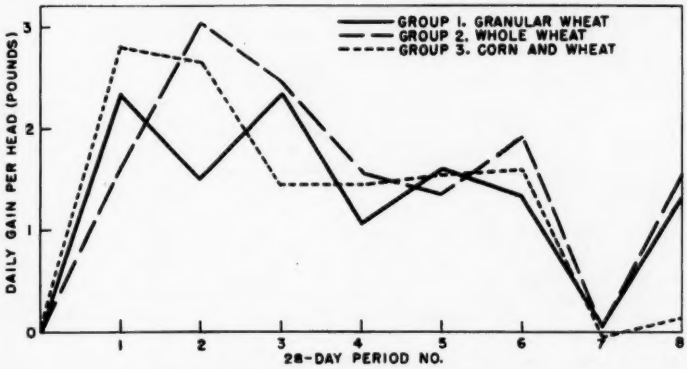

Figure 1. Average daily gain per head by periods.

the last 28 days of feeding. The low gains of the corn-wheat slop fed steers during the last 56 days were attributed largely to the low percentage of solids in the slop and high acidity.

There was no appreciable difference in the rate of slop consumption by the three groups. The greatest consumption of all groups was in the third period when it averaged 22.14 gallons per head for group 1 fed the granular

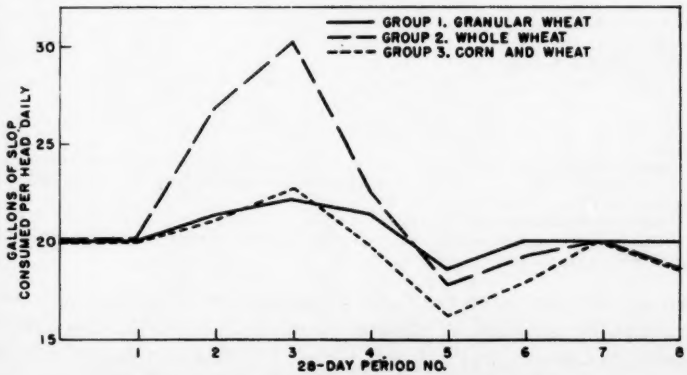

Figure 2. Average slop consumption per head by periods.

wheat slop, 30.17 gallons for the steers in group 2 fed the whole wheat slop, and 22.85 gallons for those in group 3 fed the corn and wheat slop (see figure 2). The average slop consumption per steer was nearly 22 gallons for

TABLE 2. GAINS, FEED CONSUMPTION AND EFFICIENCY OF STEERS FED FROM JULY 13, 1943, TO FEBRUARY 21, 1944 (224 DAYS)

Item	Group 1, fed distillery slop made from granular wheat	Group 2, fed distillery slop made from whole wheat	Group 3, fed distillery slop made from corn and wheat
Steers.....(number)	10	10	10
Average initial weight at feed lot...(pounds)	700	722	712
Average final weight at feed lot....(pounds)	1035	1103	1038
Average gain per head.....(pounds)	335	381	326
Average daily gain per head.....(pounds)	1.50	1.70	1.45
Average market weight at Louisville.(pounds)	996.0	1064	1020
Average shrinkage per head.....(pounds)	39.4	39.1	17.6
Average shrinkage per head.....(percent)	3.81	3.55	1.70
Total feed consumed per head:			
Distillery slop.....(gallons)	4578	4915	4370
Hay.....(pounds)	1128	1123	1128
Salt.....(pounds)	26	26	26
Limestone flour[1].....(pounds)	5.1	5.1	4.5
Average ration:			
Distillery slop.....(gallons)	20.44	21.94	19.51
Hay.....(pounds)	5.04	5.01	5.04
Salt.....(pounds)	.12	.12	.12
Limestone flour[1].....(pounds)	.10	.10	.10
Feed consumed per 100 pounds gain:			
Distillery slop.....(gallons)	1364	1293	1343
Hay.....(pounds)	336	295	347
Efficiency of gain[2].....(pounds)	12.78	13.72	12.85
Dressing percentage[3].....	60.76	61.68	60.20
Slaughter grade on hoof[4].....(score)	17	16.2	16.8
Carcass grade[4].....(score)	16.2	14.4	15.2

[1] Limestone flour fed in the slop only during 84 days. During the other 140 days the limestone was offered ad libitum.

[2] Based on pounds steer gain produced from 100 pounds of total digestible nutrients consumed. The following estimates of lbs. of T.D.N. per 100 lbs were used: Distillery slops, 6.3; hay (Lespedeza and grass), 50.0. The slops were figured at 8.5 pounds per gallon.

[3] Based on cold carcass and sales weights at market.

[4] Grade scores: Choice, 8–12, inclusive; Good, 14–18 inclusive; Medium slaughter steer grades or Commercial carcass grades, 20–24, inclusive.

group 2 as compared to about 20½ for group 1 and 19½ for group 3 (see table 2). The steers fed the whole wheat slop had a higher dressing percent and their carcasses graded slightly higher. All groups dressed better than 60 percent and the carcasses of each group fell within the Good grade.

Summary

The results of this experiment indicated that distillery slops may be used for steer fattening rather satisfactorily even when depended upon to furnish most of the dry matter in the ration. In this test about 5 pounds of lespedeza-grass hay per head daily seemingly were sufficient to meet the carotene requirements and prevent any vitamin A deficiency. The average carotene content of the hay was 101.5 micrograms per 100 grams. The daily intake of carotene contained in the hay is estimated as approximately 6 times that in the slop from granular wheat and 1.5 times that from corn and wheat.

The test also indicated that wheat slops which were considered by practical feeders to be much inferior to slops made from strictly corn mashes may compare rather favorably with them. Most of the nutritional disturbances reported by the cattle feeders in their first experience with the wheat slops were evidently due to a lack of carotene in the ration. This evidently can be overcome by feeding small quantities of good quality roughage, or by feeding low quality roughages supplemented with sufficient fish oil to make up the deficiency of carotene.

The test further suggests that when Good grade feeder steers of around 700 pounds weight are used, the feeding period should not extend beyond approximately 180 days.

The use of distillery slops in cattle feeding in areas adjacent to the distilleries can contribute materially to the potential beef supply. In war times when much of the feed supplies commonly used for beef production is diverted to other channels, the efficient utilization of distillery slops for this purpose is especially to be recommended.

SOME FACTORS THAT INFLUENCE THE PRODUCTION OF STEERS FROM PASTURE

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PROBLEMS dealing with beef production from pasture have usually been attacked on a single factor basis. The numerous investigations with winter rations have generally aimed to have average winter gains reasonably close together within a given trial. Similarly, grazing rates have been compared by using the same kind of steers on pasture lots of different sizes. In the grazing section of Virginia conditions vary from farms where an abundance of winter feed can be produced to those with a shortage of tillable land. An investigation which attempts to find optimum conditions for steer production in this area must consider more than one factor at a time.

Since Yates' (1935) classical paper, the factorial design has been used to a limited extent in animal husbandry research and extensively in some other fields to solve problems that required the simultaneous study of two or more factors. This paper reports the data obtained in the first year of a factorial investigation of three factors believed to be important in the production of slaughter steers from pasture. The purpose of the investigation was to study the effect of the following factors on the cost of production, annual gain and market grade of pasture-fattened steers: 1. Age of feeder. 2. Gain in weight during the winter. 3. Method of grazing.

Experimental Plan

The experiment was intended to cover the four-year period beginning with autumn 1942 and was to be conducted in a similar manner each year. Results in the first year are presented here. For brevity each factor is designated by a letter with a subscript.

Age of feeder

Good to choice Hereford steers of two ages, yearlings (A_1) and two-year-olds (A_2), weighing 738 ± 7[3] and 970 ± 10 pounds respectively were used. The steers were purchased from local farms where they had been grazed during the previous summer.

[1] The authors are Research Associate, Iowa State College and formerly Assistant Animal Husbandman, Virginia Agricultural Experiment Station, Associate Animal Husbandman and Animal Husbandman, Virginia Agricultural Experiment Station, respectively. The assistance and advice of Dr. Gertrude Cox, Department of Experimental Statistics, North Carolina State College, in planning the design of this experiment is gratefully acknowledged.

[2] Blacksburg, Virginia.

[3] Standard error of the mean.

Winter feeding

The animals were kept together on pasture from the time they were purchased in October until early December when winter feeding was started. Individual feeding was practiced throughout the wintering period with all steers within an Age-Winter Feeding Level group receiving the same daily ration. Three feeding levels were used with the objective of having one group of steers from each age level make the following average gains for the winter feeding period: F_0—maintenance. F_{50}—fifty pounds gain. F_{100}—one hundred pounds gain. The steers were confined in stanchions for feeding without any assignment as to position. Because the steers could not be caught, especially in the early part of the feeding period, without feed in the mangers to induce them to put their heads in the stanchions, a basal amount of silage was put in each manger before the animals entered the barn. Each one was caught in which ever manger he chose, identified and given enough additional feed to bring the ration to the required amount. They were kept in the stanchions over night and released after the morning feed had been consumed. When not in the barn for feeding they were kept as one herd in a two-acre lot.

Grazing treatments

The grazing treatments were achieved by the use of pasture lots in each of which were grazed six steers, one from each of the age-winter feed groups. Thus, each of the pasture lots contained steers representing all possible combinations of the other two factors. The grazing treatments were: G_1—ten acres to be grazed continuously for the entire grazing season. G_2—fifteen acres, ten acres to be grazed for the entire grazing season and five acres to be grazed from July 1 to the end of the grazing season. G_3—fifteen acres to be grazed for the entire grazing season. G_4—twenty acres to be grazed for the entire grazing season. G_1, G_3, and G_4 provide an estimate of the effect of rate of grazing. G_2 was introduced to measure the effect of using part of the permanent pasture as supplementary pasture during the summer and fall instead of using all available pasture for the entire period.

It is recognized that forage production might vary widely among lots of these sizes even though soil type and topography are similar. In order to eliminate some variation from this source, the entire area was top dressed with T.V.A. triple superphosphate at the rate of 400 pounds (182 lbs. P_2O_5), per acre in the winter preceding the first grazing season.

Replication and assignment of steers to treatments

A rectangular block of permanent pasture with a wooded area along one side and a stream along the other was selected to provide the pasture lots.

This area was divided in the middle to provide two sixty-acre replicates. The lots were randomized as to position within each replicate by drawing numbers from a hat. Since all lots were the same length with water at one end and shade at the other, the size was determined by the width required. The lots fell in this order:

Replicate I	Replicate II
G_2 G_3 G_4 G_1	G_3 G_4 G_1 G_2

The steers were randomized to the different treatments at the beginning of the winter feeding period. As the two age groups were to be equally represented on both replicates, steers in each age group were randomized to replicates and other factor combinations. This provided one steer per treatment combination for each replicate, and required a total of 48 steers.

Results and Discussion

Winter gains

Weight increase and feed consumption during the winter feeding period by groups fed the same amount of feed are shown in table 1. It is to be expected that steers of the same age will vary at least a little in their ability to utilize feed and also that arbitrary control of feed consumption will not quite succeed in making both ages within a feeding level gain exactly the same. The differences between feeding levels is not as great as was intended,

TABLE 1

Age	Expected gain	Average winter gain (lbs.)	Feed consumed by each steer		
			Corn silage (lbs.)	Mixed hay (lbs.)	Grain (lbs.)
Yearlings	none	14.1	1966	551	none
Two-yr.-olds	none	7.2	2376	662	none
Yearlings	50 pounds	40.8	2528	700	240
Two-yr.-olds	50 pounds	60.8	2938	811	240
Yearlings	100 pounds	83.1	2938	811	556
Two-yr.-olds	100 pounds	97.5	3348	922	556

but the trend is very close to linear. The analysis of variance of winter gains (table 2) based on the grouping of table 1 shows considerable variation within subclasses (among steers of the same age and fed the same ration). That this variation together with that between ages within feeding levels operates to modify the symmetry of the design is shown by the data in table 3. If winter gain has any effect on a variable used to measure treatment effects,

TABLE 2. ANALYSIS OF VARIANCE OF WINTER GAINS

Source of variation	Degrees of freedom	Sums of squares	Mean squares
Age	1	1,008	1,008
Winter feeding levels	2	50,722	25,361
$A \times F$ Interaction	2	1,607	803
Within sub-classes	42	19,225	457

the value of a particular treatment may be increased or decreased by winter gains which were above or below the mean for the feeding level represented. Because of these inequalities in gains, analysis of covariance with deviations from mean gain within each feeding level as the independent variable was used to adjust the measurement of treatment effects before their significance was estimated. This provides statistical control of variations in winter gain without removing any effects that winter feeding levels may have had on winter gain.

One interesting feature in the analysis of winter gains is the size of the variance (table 2) among steers within subclasses. The observed value is less than half the size of the variance usually found among steers fed in groups. Individual feeding may have possibilities for improving the efficiency and precision of feeding trials by controlling the effect of variation in amount of feed eaten. This can be done, either by feeding all steers the same amount, or by regression, depending on the answers required.

Summer gains

The gains made by steers during the grazing period are used here to measure the effect of the treatments on weight increase. Annual gain is

TABLE 3. MEAN WINTER GAIN OF STEERS ON EACH TREATMENT COMBINATION (IN POUNDS)

Summer grazing treatment	Winter feeding levels						Summer grazing treatment means
	F_0		F_{50}		F_{100}		
	Age		Age		Age		
	A_1	A_2	A_1	A_2	A_1	A_2	
G_1	29	−13	40	41	90	74	43
G_2	3	00	50	76	89	82	50
G_3	11	12	32	62	60	113	48
G_4	14	30	40	64	93	122	61
Means	14	7	41	61	83	97	50.6

probably a better measure of the overall effect from a descriptive standpoint, but it has the disadvantage of including winter gain as an element. Because of this feature total gain and winter gain are correlated regardless of the relation between the latter and summer gain. Annual gains may be obtained when they are desired or needed by combining winter and summer gains on the basis of their relations as determined from the data.

Summer gains by treatment combinations are shown in table 4. The analysis of variance of summer gains adjusted for intra group variations in winter gain (table 5) show highly significant ($P<.01$) and significant

TABLE 4. MEAN SUMMER GAIN OF STEERS ON EACH TREATMENT COMBINATION (IN POUNDS)

Summer grazing treatment	Winter feeding levels						Summer grazing treatment means
	F_0		F_{50}		F_{100}		
	Age		Age		Age		
	A_1	A_2	A_1	A_2	A_1	A_2	
G_1	308	330	288	332	288	308	309
G_2	354	314	272	318	277	260	299
G_3	352	324	322	324	315	300	323
G_4	350	388	350	298	278	322	331
Means	341	339	308	318	290	298	315.6

TABLE 5. ANALYSIS OF VARIANCE AND COVARIANCE OF DEVIATIONS FROM MEAN GAIN WITHIN WINTER FEEDING LEVELS (X) AND SUMMER GAIN (Y)

Source of variation	Degrees of freedom	S_x^2	S_{xy}	S_y^2	Adjusted mean Y^2
Replicates	1	456	−503	554	
Age (A)	1	1008	582	336	1376
Winter feeding levels (F)	2			17316	8658**
Grazing treatments (G)	3	1906	2320	7246	3372*
Interaction					
$A\times F$	2	1607	726	328	844
$A\times G$	3	4071	−2668	2928	394
$F\times G$	6	1724	−814	3763	570
$A\times F\times G$	6	1399	1542	10034	2024
Error	23	12669	−8063	28182	1048[1]

* Significant ($P<.05$).

** Highly significant ($P<.01$).

[1] As the adjusted mean squares represent estimates of variances after adjustment for regression of summer gain on winter gain within winter feeding levels, there are 22 degrees of freedom for error.

($P < .05$) effects for winter feeding levels and summer grazing treatments respectively. Neither age effect nor any of the interaction effects was significant. Snedecor's (1939) method of adjustment for regression was used to obtain the adjusted mean squares.

Winter feeding levels reduced summer gains in proportion to the amount of gain they produced in the wintering period with no significant departure from linearity. The data on feed required to produce the different winter gains is not considered to be sufficient as yet for analysis of the relation of this factor to the cost of production. It is planned, however, to use such information for this purpose at the end of the experiment when feed requirements for the four winters are available. In this study an increase of 80 pounds in winter gains reduced summer gains by 46 pounds, which leaves 34 pounds as the net increase for the year. On this basis, annual gains are increased .42 pounds for each pound gained during the winter feeding period. This is in general agreement with the work of Sheets and Tuckwiller (1924) as well as that of several others who have reported studies of the relation between winter and summer gains of steers fattened on pasture.

The effectiveness of the covariance analysis in eliminating the disturbing influence introduced by variation of winter gains within treatments is demonstrated by the variance for grazing treatments before and after adjustment for differences in this respect. Regression of summer gain on winter gain within winter feeding levels turns out to be $-.64$, not greatly different from the relation found in the study of winter-feeding levels. When the data in tables 3 and 4 are considered with this regression in mind, it can be seen that the summer gain value of G_1 is too large and that of G_4 too small. The other two grazing treatments are reasonably close to the general mean winter gain. After they are adjusted for regression of summer gain on winter gain within winter feeding level these means are as follows: $G_1 = 304$ pounds. $G_2 = 299$ pounds. $G_3 = 321$ pounds. $G_4 = 337$ pounds.

The three factor interaction ($A \times F \times G$) is not significant but is large enough to suggest that the general error term may not be appropriate for testing the difference associated with each degree of freedom for grazing treatments. It is possible, because of the symmetrical arrangement, to get a valid error term for a "t" test of each difference that goes with each main effect degree of freedom. Since G_1, G_3 and G_4 are alike except for constant differences in size, the following test will show whether the effect of increasing the acreage per steer is significant and also whether it is linear.

$$\frac{\sum_{1}^{12}(G_4 - G_1)}{12} = 32.72 \qquad t = \frac{32.72}{12.14} = 2.69^{+} \quad P < .01$$

$$\frac{\sum_{1}^{12}(G_4 - 2G_3 + G_1)}{24} = -.38.$$

Increasing the amount of pasture from 1⅔ to 3⅓ acres per steer gave an increase of 19.6 pounds for each additional acre. The intermediate acreage gives a result so near (i.e.—.38 is close to zero) the average of the two extremes that there is no indication of curvilinearity.

G_2, equal in area to the mean of the other grazing treatments, represents a different method. The difference between the mean of G_2 and the mean of the other G's measures whether deferred grazing produced a special effect. The "t" test turns out to be:

$$\frac{\sum_{1}^{12}(G_1 + G_3 + G_4 - 3G_2)}{36} = 12.47$$

$$t = \frac{22.47}{11.28} = 1.99 \qquad .10 > P > .05.$$

This hints that withholding steers from part of the pasture until July 1 may actually decrease summer gains.

Carcass grades

The carcasses were graded[5] after 36 hours in the cooler at a local packing plant where the steers were slaughtered. The grades ranged from choice to low good with numerical values of 10, 12, 14, 16, and 18 for choice, low choice, high good, good and low good respectively.

The only consistent differences with respect to grade (table 6) are those associated with age. The older steers (2-yr.-olds at the beginning of the experiment but 3-yr.-olds when slaughtered) had significantly ($P < .05$) (table 7) better carcasses than those a year younger, the difference amounting to ¼ of a grade.

The significant ($P < .05$) interaction of winter feeding level with summer grazing treatments is difficult to interpret. The data with respect to gain would lead one to expect the better carcasses from those treatments with the largest gain. On this basis, two treatments in particular, are markedly discrepant from expected. Some values in the *F-G* cells (table 6) depart rather

[4] Of the 12 degrees of freedom for each grazing treatment comparison within replicate, age and winter feeding, one is associated with the regression of summer gain on winter gain and one with the mean difference. Each error term, with 10 degrees of freedom, is an estimate of the standard deviation of differences between steers alike in all respects except the one being tested.

[5] Grades were assigned by a representative of the Federal Grading Service, Bureau of Animal Industry, U. S. Department of Agriculture.

TABLE 6. MEAN CARCASS GRADES[1] OF STEERS ON EACH TREATMENT COMBINATION

Summer grazing treatment	Winter feeding levels						Summer grazing treatment means
	F_0		F_{50}		F_{100}		
	Age		Age		Age		
	A_1	A_2	A_1	A_2	A_1	A_2	
G_1	15	16	16	15	17	15	15.7
G_2	15	14	14	13	16	15	14.5
G_3	17	14	17	14	13	12	14.5
G_4	17	17	17	14	15	12	15.3
Means	16.0	15.2	16.0	14.0	15.2	13.5	15.0

[1] Numerical values of 10, 12, 14, 16, and 18 represent choice, low choice, high good, good and low good, respectively.

widely from this expectation. F_0G_4 and $F_{100}G_1$ are too large while F_0G_2 and $F_{50}G_2$ are too small. Because of these discrepancies no conclusions as to the effect of either winter feeding level or grazing treatment on carcass grade seem justified now.

The factorial design for experiments with large animals

An experimental design which permits a group of animals to answer several questions at the same time offers possibilities for expanding some

TABLE 7. ANALYSIS OF VARIANCE AND COVARIANCE OF DEVIATION FROM MEAN WITHIN WINTER FEEDING LEVELS (X) AND CARCASS GRADE (Z)

Source of variation	Degrees of freedom	S_x^2	S_{xz}	S_z^2	Adjusted mean Z^2
Replicate	1	456	24.67	1.33	
Age	1	1008	−165.00	27.00	16.98*
Winter feeding levels	2			12.50	6.25
Grazing treatments	3	1906	.50	12.67	4.20
Interactions:					
$A \times F$	2	1607	−75.00	3.50	0.23
$A \times G$	3	4071	−144.17	5.67	0.23
$F \times G$	6	1724	−107.75	44.83	6.80*
$A \times F \times G$	6	1399	57.67	9.83	2.27
Error	23	12669	−364.00	66.67	2.56[1]
Total	47		−1594.00	184.00	

* Significant ($P < .05$).

[1] Adjusted error mean square has 22 degrees of freedom.

experimental programs without increasing the size of the herd. Crampton (1942) reported a factorial arrangement in which 96 pigs gave direct comparisons among a set of variables that would have required 480 pigs in a series of single factor studies. In this experiment, 48 steers and 120 acres of land permit comparisons, which, on a single factor basis, would require 144 steers and 360 acres. Along with this increased efficiency in the use of experimental material, there is the advantage of being able to estimate interactions.

Fisher (1937) emphasizes a third advantage of the factorial over single factor designs which has an important hearing on the practical application of experimental results. This is that a wider inductive basis for conclusions may be attained without impairing the precision of the experiment. For example, the data obtained in this study on the effect of increasing the pasturage per steer have application to a wider variety of farm conditions than would be the case with data from an experiment in which age and winter gain were constant. It is because of this broader scope that the factorial loses none of its usefulness in the absence of interactions.

Is precision lost by increasing the number of questions to be answered without increasing animal numbers? The answer depends on the nature of the experimental material. With field plots, position effects (variability in soil fertility, slope, exposure, etc.) may reduce precision when the treatment combinations are large. With many animal experiments, position effects may be controlled by handling all treatment combinations as one herd. In this experiment with 24 treatment combinations, reasonably small differences appear to be significant. The coefficient of variability[8] of mean summer gain, 10.3 per cent, is not as great as that found by the authors on a within lot basis in several previous grazing experiments. If position effect is small or unimportant the ratio between values of "t" for different degrees of freedom is a measure of relative precision. A single factor experiment with 48 steers on two replicates would yield a maximum of 44 degrees of freedom for estimation of error comparable to the 22 in these data. The "t" values ($P = .05$) for 44 and 22 degrees of freedom, 2.015 and 2.074, respectively, show a maximum loss of precision of about three percent.

Three things—the questions to be answered, the material available, and the conditions under which the work must be done—usually determine the kind of design that must be used. If, as is the case in many situations, the experimenter has little or no choice of materials or conditions, he may have to abandon some of the questions unless he can devise a design which circumvents these limitations. The variety of designs now in use were devised to meet the limitations on experimental materials and conditions without abandoning pertinent questions. The factorial is one which is usually adapted

[8] From tables 4 and 5 the coefficient of variability turns out to be $\sqrt{1048/315.6(100)} = 10.3$ percent.

to the study of two or more variables under ordinary conditions. The present study indicates that it may be very useful for a large variety of animal experiments. By combining single factor experiments into an arrangement such as the one used here, the output of an experimental program may be doubled or trebled without any important loss of precision.

Summary

A factorial design used to measure the effects of three factors (age of feeder, rate of gain during winter and method of grazing) on the gain in weight and carcass grade of steers fattened on pasture shows:

1. That no significant difference occurred in gain between yearling and two-year-old steers, but that the latter were significantly fatter, the difference amounting to ¼ of a carcass grade.

2. That each pound of winter gain reduced summer gain by .58 pounds and increased annual gain .42 pounds.

3. That increasing the acreage from 1⅔ to 3⅓ acres per steer increased gains by 19.6 pounds for each extra acre.

4. That no advantage in gain resulted from withholding steers from part of the pasture until July 1.

5. That covariance analysis was effective in adjusting variances for variation in winter gain within feeding levels. The adjusted mean squares for error were reduced by 14 and 12 per cent for summer gains and carcass grades respectively.

6. That individual feeding may offer a means of increasing precision in feeding trials by reducing the variance within treatments.

7. That the factorial was more efficient in the use of facilities and provided data which had wider application to practical conditionst han would have been the case with a series of single factor experiments. Making the same number of steers answer three questions and also the interactions between them gave information on each question only three per cent less precise than if the same steers had been used to answer one of these questions alone.

Literature Cited

Fisher, R. A. 1937. The Design of Experiments. Oliver and Boyd, London.

Crampton, E. W. 1942. The Design of Animal Husbandry Experiments. JOURNAL OF ANIMAL SCIENCE, 1: 263–276.

Sheets, E. W. and R. H. Tuckwiller. 1924. Winter Rations and Their Influence on Pasture Gains of Two-Year-Old Steers. U. S. Dept. of Agr. Bull. 1251.

Snedecor, George W. 1940. Statistical Methods Applied to Experiments in Agriculture and Biology. Collegiate Press, Inc., Ames, Iowa.

Yates, F. 1935. Complex Experiments. Supp. Jour. Roy. Statis. Soc., 2: 181–247.

———. 1937. The Design and Analysis of Factorial Experiments. Imp. Bur. Soil Sci. Tech. Comm. 35.

THE RELIABILITY OF ESTIMATES OF THE PROPORTION OF MORPHOLOGICALLY ABNORMAL SPERMATOZOA IN BULL SEMEN

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MUCH new information on the criteria of semen quality which are important in the assay of potential fertility of a semen sample is now being obtained in artificial breeding. Attention recently has been focused on the physiological approach (Walton and Edwards, 1938; Beck and Salisbury, 1943; Comstock *et al.*, 1943; and VanDemark *et al.*, 1945) rather than upon the structure of spermatozoa as was the case earlier (Williams and Savage, 1927; Webster, 1932; Lagerlof, 1936). However, no one has yet produced conclusive evidence that attention no longer need be paid to the proportion of morphologically abnormal spermatozoa when such an assay is made (Comstock *et al.*, 1943; Mercier, 1944; VanDemark *et al.*, 1945).

In spite of the numerous studies which have been made on the morphological examination of spermatozoa, until recently no serious attempt has been made to determine the minimum number of sperm cells which should be examined on a single smear to give a reliable estimate of the proportion of morphologically abnormal spermatozoa on the smear. Some workers have examined microscopically 1000 individual sperm cells (Lagerlof, 1936) others have examined 333 spermatozoa and multiplied the data by 3 to obtain the proportion per thousand (Herman and Swanson, 1941); and many others have observed 500 individual cells. Although the proportion frequently has been given as the number of abnormally-formed spermatozoa per thousand, the examination of 500 sperm cells and the expression of the proportion of morphological abnormalities in percentage seem to have been the general rule.

After the present investigation was started, Comstock *et al.* (1943) presented data showing the theoretical statistical error to be expected when groups of 25, 50, 100, 250, 500 and an infinite number of spermatozoa were examined. They used the statistical error actually found when the proportion of morphological abnormalities was determined after examination of 500 spermatozoa in each semen sample. They found that the examination of more than about 100 sperm cells per sample would be "an impractical refinement because it results in a very small reduction in the standard error of the estimate obtained." The increase in reliability when more than 100 sper-

[1] The authors wish to acknowledge the aid of Dr. F. Irvine Elliott in making certain of the semen smears.

matozoa were examined would not be commensurate with the work involved.

The present report deals with a study on bull semen undertaken to answer the problem of how many spermatozoa must be examined on a single smear to obtain a reliable estimate of the proportion of abnormally-formed spermatozoa on that slide.

Procedure and Results

The junior author, who had no previous experience in this kind of work, made all of the examinations reported. Two different studies were made. The first, on a limited number of semen samples, was designed to determine how many spermatozoa must be examined by an uninitiated observer to produce reliable data. It had earlier been shown from this laboratory (Salisbury *et al.*, 1942) that the method of making the smears might influence the number of abnormalities seen. It was specified that no more spermatozoa need be examined on a single smear than would give an estimate of the proportion of abnormally-formed spermatozoa of as high an order of repeatability as would be obtained in making two smears from the same semen sample.

Two smears from each of 30 ejaculates collected from 14 different bulls were made by the best method previously described (Salisbury *et al.*, 1942), and were stained with the same stains, although the order of staining was reversed (Mercier, 1944). Five hundred spermatozoa were examined on each slide. The data were recorded for each smear in consecutive units of 100 sperm cells classified as to morphology. Correlations then were calculated between the number of abnormally-formed spermatozoa found in the first unit of 100 in each sample, the average of the first and second units of 100, the average of the first, second and third units, etc., and the average number of morphological abnormalities found in the entire 500 spermatozoa examined on one slide. Finally the correlation between the proportion of morphologically abnormal spermatozoa found on one slide and on the other made from the same semen sample was then calculated from the data based on the examination of 500 spermatozoa on each of the two slides. The results are shown in table 1.

The data show that the reliability of classification when but 100 spermatozoa were examined on one slide was greater than was the accuracy of making two smears from the same ejaculate of semen, and examining 500 cells on each one. The results clearly indicated that the problem of sampling the semen ejaculate was a more important one than was the examination of more than 100 sperm cells per ejaculate.

The correlation coefficient for the proportion of abnormally-formed spermatozoa between the two slides was lower than had been expected on the

basis of previous work in this laboratory. This result may have been due to the fact that no record was made of which of the two slides observed was the bottom and which the top when the smears were made. It is possible that the upper of the two slides used in making semen smears might differ

TABLE 1. CORRELATION COEFFICIENTS FOUND IN THE FIRST STUDY BETWEEN TOTAL OF FIRST SMEAR AND COMBINATIONS OF UNITS AND BETWEEN FIRST AND SECOND SMEARS

Units correlated	Units correlated				
	First unit	First 2 units	First 3 units	First 4 units	Total of 5 units
	r	r	r	r	r
Total of 5 units in first smear	0.88**	0.90**	0.98**	1.0**	—
Total of 5 units in second smear	—	—	—	—	0.80**

** Significant at the 1.0% level of probability.

significantly in the proportion of morphological abnormalities from the lower one, but the data from this study cannot be used to answer that question.

An analysis of variance of the proportion of total morphologically abnormal spermatozoa for the 30 first and second slides examined shows no significant difference between them, the mean being 22.2 percent and 21.1 percent respectively.

The second study of this investigation dealt with the accuracy of classifying bovine spermatozoa as to structure which may be expected as the investigator gains experience. The procedure was similar to that used in the

TABLE 2. CORRELATION COEFFICIENTS FOUND IN THE SECOND STUDY BETWEEN THE TOTAL OF THE SMEAR AND COMBINATIONS OF UNITS OF 100 SPERMATOZOA OBSERVED

Unit correlated	First unit	First 2 units	First 3 units
	r	r	r
Total of 5 units in the smear	0.93**	0.98**	0.99**

** Significant at the 1.0% level of probability.

previous study except that only one smear from every ejaculate was used. On each of 75 smears 500 cells were examined and the data recorded for each unit of 100 sperm cells. The correlations determined from these data are shown in table 2.

The correlation coefficients were larger in this series of ejaculates between the proportion of morphological abnormalities recorded in the first one, first two, first three units of 100 cells examined, and that of a total of 5 units than were found in the first series of ejaculates. As a matter of fact, the correlation coefficient between the proportion of morphologically abnormal spermatozoa of the first and that of the 5 units of this series ($r = 0.93$) was greater than that found between the proportion of morphological abnormalities of the first 2 units of 100 and the total of 5 units in the first series ($r = 0.90$). These results indicated that training and experience increased the accuracy with which morphologically abnormal sperm cells were determined on a single smear.

Summary

An experiment was conducted to determine how many spermatozoa must be examined on a single bull semen smear to obtain reliable data on the proportion of morphologically abnormal spermatozoa found on that smear. Five hundred spermatozoa on each smear were examined and classified as to structure. The data were recorded in units of 100 spermatozoa.

The results showed that the proportion of abnormally-formed spermatozoa calculated on the basis of the examination of a single unit of 100 spermatozoa was as reliable as the ability of a single investigator to make two slides from the same ejaculate of semen and to examine 500 cells on each one. Also, the data showed that improvement in the reliability of making the morphological classification of spermatozoa was rapid as an investigator gained experience.

Literature Cited

Beck, G. H., and G. W. Salisbury. 1943. Rapid Methods for Estimating the Quality of Bull Semen. Jour. Dairy Sci. 26: 483–494.

Comstock, R. E., W. W. Green, L. M. Winters, and A. W. Nordskog. 1943. Studies of Semen and Semen Production. Univ. of Minn. Agr. Exp. Sta., Technical Bull. No. 162, 55 pp.

Herman, H. A. and Eric W. Swanson. 1941. Variations in Dairy Bull Semen with Respect to its Use in Artificial Insemination. Mo. Agr. Exp. Res. Bull. No. 326.

Lagerlof, Nils. 1936. Sterility in Bulls. Vet. Rec., 48: 1159–1173.

Mercier, Ernest. 1944. The Relationship between the Proportion of Morphologically Abnormal Spermatozoa and other Criteria of Bull Semen Quality. A thesis presented to the Faculty of the Graduate School of Cornell University for the Degree of Master of Science in Agriculture, 66 pp.

Salisbury, G. W., E. L. Willett, and Jack Seligman. 1942. The Effect of the Methods of Making Semen Smears upon the Number of Morphologically Abnormal Spermatozoa. Jour. An. Sci., 1: 199–205.

VanDemark, L. N., Ernest Mercier, and G. W. Salisbury. 1945. The Methylene Blue Reduction Test and its Relations to other Measures of Quality in Bull Semen. Jour. Dairy Sci. 20: 121–128.

Walton, A. and J. Edwards. 1938. Criteria of Fertility in the Bull. The Exhaustion Test. Amer. Soc. Prod., Proc., 31: 254–259.

Webster, W. Maurice. 1932. Bovine Sterility in New Zealand. Austral. Vet. Jour., 8: 199–222.

Williams, W. W. and Alfred Savage. 1927. Methods of Determining the Reproductive Health and Fertility of Bulls. A Review with Additional Notes. Cornell Vet., 17: 374–385.

NEWS AND NOTES

The dates of November 30 and December 1, 1945, have been selected tentatively for the next annual meeting of the American Society of Animal Production. However, it now seems doubtful that the war situation will change sufficiently to obtain approval of the Office of Defense Transportation, in time to organize the meetings. If meetings are held, they will be at the Hotel Morrison in Chicago. Sectional chairmen are listed below:

Animal Breeding	R. E. Comstock, North Carolina
Beef Cattle	C. W. Hickman, Idaho
Dairy Cattle	J. H. Hilton, North Carolina
Extension	L. A. Richardson, Tennessee
Horses and Mules	Wayne Dinsmore, Horse and Mule Ass'n of America, Chicago, Illinois
Meats	B. W. Gardner, Jr., Subsistence Research and Development Laboratory, Chicago Quartermaster Depot, Chicago, Illinois
Nutrition	J. L. Krider, Illinois
Pasture and Range	Marvel Baker, Nebraska
Sheep and Wool	J. E. Nordby, U.S.D.A., Dubois, Idaho
Swine	H. G. Zavoral, Minnesota
Teaching	R. F. Cox, Kansas

It is hoped that final notice concerning the meeting can be included in the August issue. If the meeting is to be held, members will be notified by letter at the earliest possible date.

Considerable delay in publication of recent issues of the JOURNAL OF ANIMAL SCIENCE *has resulted owing to failure of some authors to return corrected galley proofs promptly. Proofs, accompanied by reprint order and abstract for Biological Abstracts, should be mailed to the editor within three days after they are received from the printer. In the future, publication of manuscripts must be delayed until the next issue, if proofs are not returned promptly. This action is necessary to keep publication of the* JOURNAL *on schedule.*

W. C. Coffey is retiring as president of the University of Minnesota on July 1, 1945, and will be succeeded by J. L. Morrill, now president, University of Wyoming.

W. Tap Bennett, formerly of the animal husbandry staff, University of Georgia, and more recently in charge of the Pine Mountain project of the Farm Security Administration, near Warm Springs, Ga., became director of agricultural development, Central of Georgia Railway Co., with headquarters at Savannah, Ga., November 1, 1944.

George K. Dillard, formerly assistant animal husbandman, Coastal Plain Experiment Station, Tifton, Ga., has been appointed livestock development agent, Atlantic Coast Line R. R. Co., with headquarters at Jacksonville, Fla.

W. V. Lambert, formerly associate director of the Purdue University Agricultural Experiment Station, is now Assistant Administrator of the Agricultural Research Administration, U. S. Department of Agriculture, Washington, D. C.

In the November issue, it was stated that Mark A. McCarty had joined the staff at Washington State College. This was an error. Mr. McCarty is now economist with the Livestock Section, Office of Price Administration, Washington, D. C.

Joe Muir has been appointed extension animal husbandman at Washington State College. He was formerly country agent at Panguitch, Utah.

F. I. Dahlberg is now acting head of the animal husbandry department at Texas A. & M. College. J. C. Miller, formerly acting head of this department, is now head of the animal husbandry department at the University of Tennessee.

Guy A. McDonald, who was formerly extension animal husbandman at South Dakota State College, and more recently held a position with the Sioux Falls Stock Yards Company, has succeeded Fred H. Leinbach as director of the National Livestock Conservation Program, with headquarters at 59 E. Van Buren St., Chicago.

M. L. Dalton, formerly country agricultural agent in Henry County, Virginia, is assistant extension animal husbandman in the same State, succeeding Paul Swaffar.

J. L. Van Horn, formerly assistant professor of animal husbandry and wool technologist Montana State College, is now wool marketing specialist with the Farm Credit Administration in Washington.

Chas. N. Shepardson, formerly head of the dairy department of Texas A. & M. College, was made dean of the agricultural college of the same institution, effective December 1, succeeding E. J. Kyle, retired.

W. S. Rice, formerly extension animal husbandman at the University of Georgia, resigned February 15 to become manager of the Georgia Hereford Association.

J. J. Moxley, who has been extension animal husbandman at Kansas State College for the past 18 years, resigned, effective January 1, to devote full time to his ranching interests near Council Grove, Kansas.

D. E. Richards, formerly superintendent of the eastern Oregon Livestock Branch Experiment Station at Union, recently resigned to become manager of the Ox-Bow Ranch at Prairie City in the same State.

E. V. Vestal, formerly extension swine specialist at the North Carolina College of Agriculture, has resigned to devote his time to personal farming interests, and has been succeeded by Jack Kelley, formerly county agricultural agent in Jones County of the same State, and a graduate of the University of Kentucky.

J. L. Stansbury has been appointed emergency extension specialist in animal husbandry in the Ohio Extension Service, effective January 1, and will devote his time to the field of artificial insemination.

George Freeman, formerly county agricultural agent in Oklahoma, is now southwestern fieldman for the American Aberdeen-Angus Breeders Association.

H. M. Vollrath, formerly county agricultural agent, was made assistant extension animal husbandman in the Hawaiian Extension Service, effective November 1, 1944.

T. B. Keith (Captain) on military leave from the animal husbandry department, Pennsylvania State College, has been commended for meritorious service in connection with food supplies and reserves in France.

L. A. Kauffman, who has been secretary of the Ohio Wool Grower's Cooperative Association for the past 12 years, and formerly sheep extension specialist, Ohio Extension Service, has been given a year's leave of absence to become executive officer of the Ohio Council of Cooperatives with headquarters in Columbus.

DeWitt C. Wing, formerly on the staff of U. S. D. A. Office of Information, is now information and public relations specialist with the U. S. Office of Education in Washington.

Lorin H. Harris, formerly agent for the Fish and Wildlife Service, United States Department of Interior, and more recently research associate of the School of Nutrition, Cornell University, has accepted a position as associate professor in the animal husbandry department at the Utah State Agricultural College, Logan, Utah, and will do work on animal nutrition.

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